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FORMFIT: A MACHINE LEARNING APPROACH FOR REAL-TIME EXERCISE FORM FEEDBACK USING MEDIAPIPE

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ABSTRACT

In today's fast-paced world, many individuals struggle to find time and resources to prioritize their physical fitness. Traditional gym memberships can be costly and time-consuming, often requiring travel and adherence to fixed schedules. As a result, there's a growing need for accessible and convenient solutions that empower people to exercise effectively from anywhere. FormFit is a virtual fitness assistant designed to bridge this gap. By harnessing the power of machine learning and computer vision technologies like OpenCV and MediaPipe, FormFit offers real-time posture guidance and exercise tracking through live or recorded videos. FormFit's user-friendly interface and comprehensive exercise coverage, including pushups, jump squats, dumbbell exercises, and more, make it an invaluable tool for individuals seeking affordable, time-efficient ways to stay fit and healthy. FormFit currently supports eight exercises aimed at targeting different muscle groups like chest, waist, shoulders, etc., with repetition counting included for all these exercises. Additionally, there's potential for future expansion to include more exercises, further enhancing its versatility and effectiveness.

Keywords: Media Pipe, Exercise, OpenCV, Fitness.

I. INTRODUCTION

In today's dynamic and demanding world, where stress has become a constant companion, the importance of maintaining good physical fitness cannot be overstated. The pressures of daily life often leave individuals with limited time and energy to devote to their well-being, making it imperative to incorporate activities like walking, exercise, meditation, and yoga into our routines. The COVID-19 pandemic has sparked a renewed interest in physical fitness, prompting many individuals to explore online platforms for exercise guidance. While offline training with a professional trainer remains an option, the convenience and accessibility of virtual fitness solutions have gained popularity. However, relying solely on non-professional websites or videos can pose risks, as incorrect posture during exercises can lead to injuries and impede progress. In response to these challenges, our study proposes a posture correction system that streamlines the analysis of posture without requiring additional equipment costs. This paper focuses on providing posture correction guidelines for exercises such as push-ups, jump squats and lateral arm raises through a user-friendly interface. Real-time feedback is delivered via text prompts, ensuring users maintain correct posture throughout their workouts.

In this paper it is used integration of advanced computer vision technologies, specifically OpenCV and MediaPipe utilizing the BlazePose model. OpenCV, a robust computer vision library, facilitates color format conversion and compatibility for further analysis of video inputs. MediaPipe, employing BlazePose, identifies 33 landmark poses on the human body, serving as reference points for angle calculations and posture assessment. The BlazePose model, a lightweight convolutional neural network (CNN) architecture, plays a pivotal role in enhancing posture analysis across various exercises. Its efficiency lies in accurately identifying key landmarks on the body, which are crucial for determining the correctness of the user's posture. This analysis is conducted in real time, ensuring immediate feedback and correction if an incorrect position is detected, thus mitigating the risk of exercise-related injuries.

Furthermore, our system incorporates a continuous feedback mechanism that incrementally counts repetitions for each exercise iteration when correct form is maintained. This feature not only encourages users to exercise with proper posture but also provides repetition counting, fostering consistency and motivation in their fitness journey. Our posture correction system leverages state-of-the-art technologies to address the challenges faced by individuals seeking effective and safe fitness solutions. By combining machine learning algorithms like BlazePose with real-time feedback mechanisms, we aim to revolutionize the way users engage in physical exercise, promoting correct posture, injury prevention, and overall fitness enhancement. With FormFit's user-friendly interface and comprehensive exercise coverage, including jump squats, air bikes, alternate heel touches, shoulder taps, dumbbell lateral arm raise, dumbbell alternate side press, sit-ups with arms on chest, and push-ups, users can target

The aim of this paper is to develop a virtual fitness assistant, leveraging machine learning and computer vision technologies, to address the challenges faced by individuals in maintaining proper posture and tracking repetitions during exercise routines. The key objectives are:

1. Implement real-time posture detection to ensure users perform exercises with correct form, reducing the risk of injuries and maximizing workout effectiveness.
2. Develop a system for accurate repetition counting across various exercises and encouraging consistency in their fitness routines.

The paper is organized as Literature Review, System Design, Result analysis and future implementation, lastly conclusion

II. LITERATURE REVIEW

The paper [7] introduces a new program that uses technologies called OpenCV and MediaPipe. It helps people exercise at home by checking their posture and giving guidance without a trainer. It focuses on fixing squat and push-up positions, giving real-time advice on posture and counting workouts. In paper [8] survey explores the realm of yogic posture recognition, a burgeoning field leveraging technology to enhance yoga practice. Utilizing technologies such as Kinect, CNNs, and Mask-CNN, alongside OpenCV, this paper delves into the automated detection and analysis of yoga postures. Authors in [10] discussed about the MediaPipe Hands revolutionizes real-time hand tracking through the integration of the BlazePose hand detection model within the MediaPipe framework. The paper [9] examines the development of an AI-based exercise monitoring system employing Python modules, including MediaPipe, TensorFlow, Matplotlib, and OpenCV. The paper [1] has included the detection of human activities including running, jumping, squatting, bending to the left or right, and standing still. In one more system [2] is used to test on various exercises, such as squats, push-ups, and lunges also its used to estimate the posture of the user in different lighting conditions and is robust to occlusions and background clutter. In paper [3] the author discussed about the 3 models to find out the errors during the exercising using video-based training system. Authors in [4] focussed on machine learning for the training of Taekwondo which is a martial art using cnn algorithm. Writer of [5] developed the mobile application for tracking the exercises using the machine learning approach. The paper [6] included the real time yoga pose detection method based on the Artificial Intelligence application in a single platform.

III. METHODOLOGY

A. Data set

We have considered the real video only as input to our system. The live video is processes by the 4 steps operations as, Frame-by-Frame Analysis, Real-time Landmark Detection, Instant Feedback Mechanism, Continuous Frame Processing. For recorded video there are again 4 steps for processing the video as Frame Analysis, Landmark Extraction, Validation and Training, Dataset Augmentation.

B. System Design

The methodology employed in this paper for real-time fitness posture analysis combines sophisticated computer vision technologies, notably OpenCV, MediaPipe, and BlazePose. These technologies collectively enable the accurate assessment of posture during live video sessions, ensuring users receive timely feedback for optimal exercise performance. To begin, the system relies on high-quality hardware components such as an efficient webcam capable of capturing clear and detailed videos. Additionally, a stable internet connection is essential to support real-time processing and facilitate prompt feedback delivery to users, enhancing the overall user experience and improving fitness outcomes.

The flowchart fig 1. of our system provides a detailed overview of its operations, starting with the capture of live video footage by a webcam. This raw video data is then processed using OpenCV, a powerful computer

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vision library. OpenCV's role in the process is crucial, as it converts the video's color format from BGR to RGB, which is essential for compatibility with subsequent analysis and processing steps.

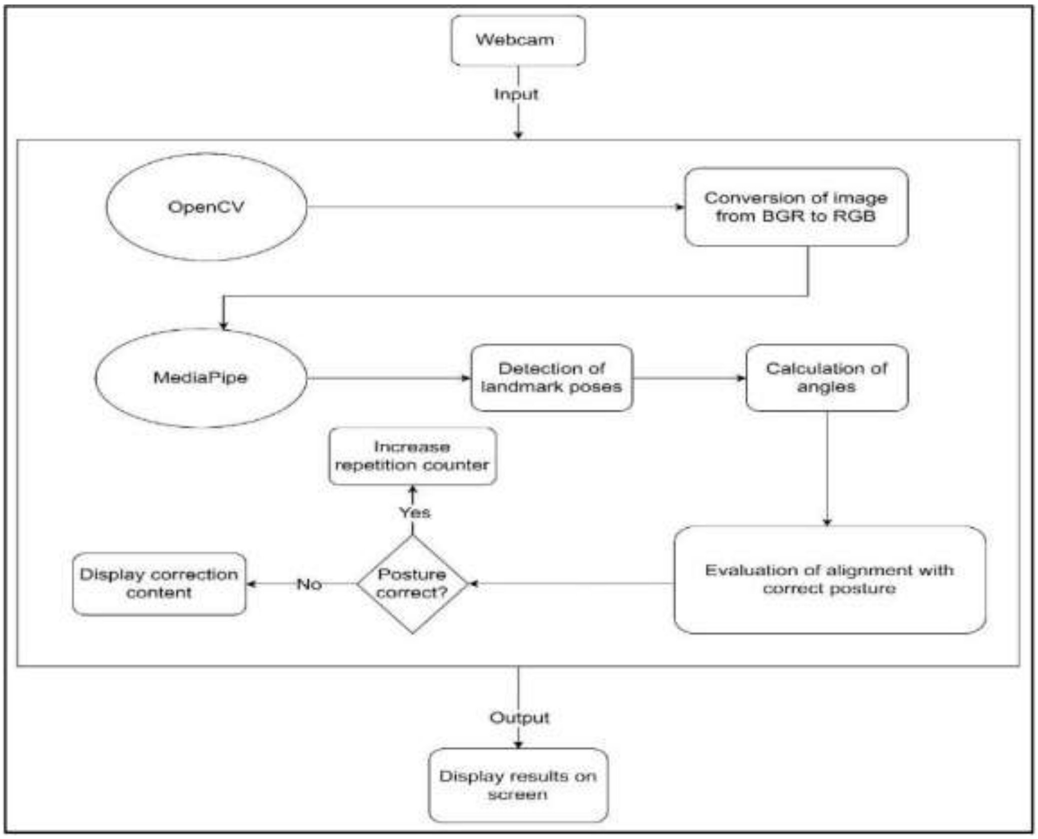

Fig 1: Methodology of pose detection and feedback mechanism

Once the video data is in the appropriate format, MediaPipe takes over, processing the videos to locate and track objects, specifically recognizing 33 landmark poses on the human body using the BlazePose model shown in fig 2. These landmark poses serve as key reference points for analyzing workout positions and determining the correctness of the user's posture during exercises. Media Pipe's sophisticated algorithms and capabilities play a vital role in ensuring accurate posture detection and analysis in real time.

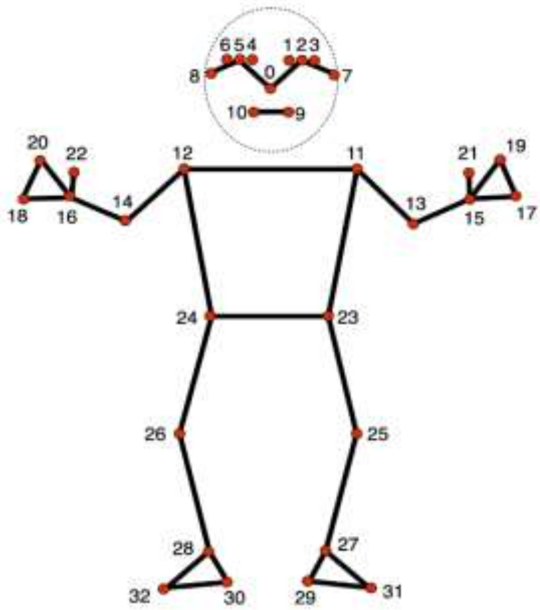

Fig 2: 33 key points detected by BlazePose

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One of the core features of our system is its continuous feedback mechanism, which provides real-time assistance to users based on their posture during exercises. If the system detects that a user's posture matches the correct form, it increments the repetition counter, indicating that a repetition has been performed correctly. On the other hand, if the system identifies an incorrect posture, no increase is made to the repetition counter, signaling to the user that adjustments are needed to achieve proper form. This feedback loop is crucial for helping users maintain correct postures, avoid injuries, and maximize the effectiveness of their workouts.

In terms of results presentation, our system displays the number of correctly performed repetitions on the screen for user review and improvement. This visual feedback enhances the user's understanding of their exercise performance and allows them to track their progress over time.

Our approach incorporates a live dataset to ensure the relevance and timeliness of the analyzed data. Recorded videos can also be used. Leveraging MediaPipe, a highly accurate tool known for its real-time object detection, facial recognition, and pose estimation capabilities, our system achieves an impressive accuracy in these tasks. This high level of accuracy builds reliability in using MediaPipe to power real-time projects, ensuring that users receive accurate feedback and guidance during their exercise sessions.

IV. RESULTS AND DISCUSSION

The exercises covered in this paper include jump squats, air bikes, alternate heel touches, shoulder taps, dumbbell lateral arm raises, dumbbell alternate side presses, sit-ups with arms on the chest, and push-ups. The primary objective of our project was to accurately track and analyze the posture of individuals performing these exercises in real-time, coupled with the capability to count repetitions automatically. Here, we present a comprehensive overview of the results obtained from our implementation, showcasing the accuracy levels achieved for each exercise across varying numbers of repetitions. Additionally, detailed visual representations in the form of images depicting the exercises with annotated accuracy percentages and heatmaps further elucidate the efficacy and performance of our posture tracking and repetition counting system.

A. Heatmap:

Among the eight exercises conducted it was observed that Side Arm Raise demonstrated the highest accuracy, achieving a perfect score of 100%. On the other hand, the exercise with the lowest accuracy was Air Bike, which achieved approximately 83%.

Fig 3: Heatmap indicating success rate for various exercises

B. Exercises

Dumbbell Lateral Raise:

Fig 4:

The logic for exercise detection involves monitoring the vertical positions of certain landmarks, particularly the shoulder and elbow landmarks (`points[12]` and `points[14]`, respectively).

Dumbbell Alternate Side Press:

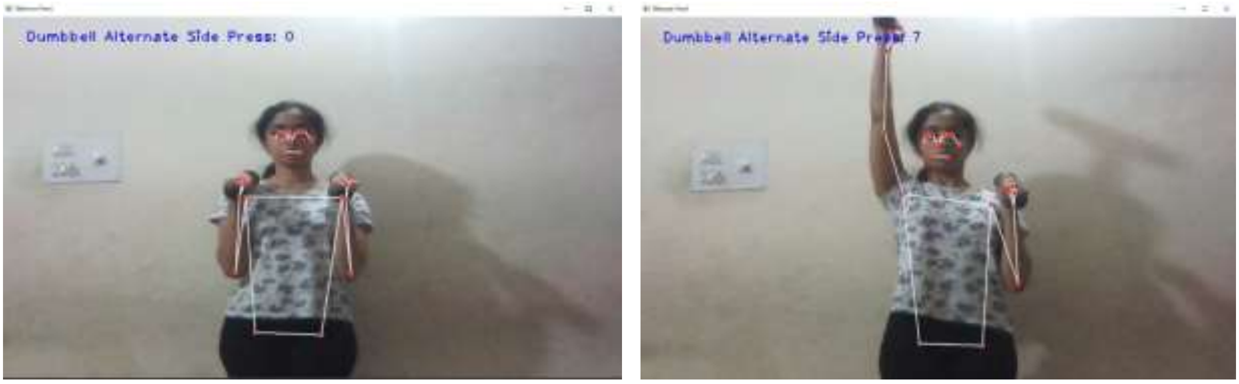

Fig 5:

The system evaluates the visibility confidence of landmarks like elbows and shoulders from a pose detection model. If these landmarks are visible with high confidence levels (above 0.7), it proceeds to check if the elbows are positioned lower than the shoulders and if one arm is raised higher than the other.

Push-Ups:

Fig 6:

The code first extracts key landmark points such as the shoulders, elbows, and wrists from the pose detection results. Then, it calculates the angles formed by these key points to determine if a push-up movement is being performed.

Jump Squats:

Fig 7:

V. CONCLUSION

The primary objective of our project was to develop a robust system capable of accurately tracking human poses and automatically counting repetitions for various exercises. We have achieved notable success in fulfilling these goals and providing valuable insights into user performance and progress. One of the key highlights of our project is the integration of pose detection algorithms, such as MediaPipe Pose, coupled with custom logic for exercise recognition and repetition counting. By utilizing pose landmarks and visibility confidence scores, our system can reliably identify specific exercise movements, including jump squats, dumbbell lateral raises, and more. This level of exercise recognition lays a solid foundation for precise repetition counting and performance analysis. The accuracy assessments conducted across different exercises and repetition ranges have showcased the robustness and effectiveness of our system. For instance, exercises like dumbbell lateral raises exhibited consistent accuracy of 100% across all repetition counts.

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