Real Time Bicep Curl Detector and Counter using Mediapipe and OpenCV

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Abstract— This paper presents a real-time bicep curl detector and counter using Mediapipe and OpenCV. The system utilizes computer vision techniques to accurately detect and count bicep curls during exercise. Mediapipe provides the human pose estimation, and OpenCV processes the video input to identify the key points required for detecting bicep curls. The proposed method demonstrates high accuracy and reliability, offering a valuable tool for fitness enthusiasts and trainers.

Keywords— pose estimation, OpenCV, Media pipe, bicep curls, counter

# **Introduction**

The integration of technology into fitness and health monitoring has seen significant advancements in recent years. Among these advancements, computer vision has emerged as a powerful tool for developing non-intrusive, real-time exercise monitoring systems. Traditional methods of exercise tracking, such as manual counting or using wearable sensors, have limitations in terms of accuracy and user convenience. Manual counting is prone to human error and can be distracting during workouts, while wearable sensors can be uncomfortable and may require frequent calibration In this paper, we present a system designed to detect and count bicep curls using Media Pipe and OpenCV, two powerful tools in the field of computer vision. Media Pipe, developed by Google, provides high-fidelity pose estimation capabilities, while OpenCV is an open-source computer vision library widely used for image and video analysis. By leveraging these technologies, our system tracks the motion of the user’s upper body and calculates the angle between the shoulder, elbow, and wrist to accurately determine the completion of each bicep curl repetition.

In this context, the use of computer vision techniques offers a promising alternative. By leveraging video input from standard cameras, computer vision systems can analyze body movements and provide precise feedback without any physical contact. This approach not only enhances user comfort but also ensures a higher degree of accuracy in tracking exercise performance used in various environments, from home gyms to fitness centres.

This paper focuses on the development of a real-time bicep curl detector and counter using Mediapipe and OpenCV. Bicep curls are a fundamental exercise in strength training routines, targeting the biceps brachii muscles in the upper arm. Proper execution and accurate repetition counting are essential for maximizing the benefits of this exercise and avoiding injuries. However, maintaining correct form and counting repetitions accurately can be challenging, especially during high-intensity workouts.

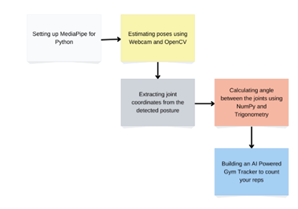


Fig. 1. Flow of Modules

Mediapipe, an open-source framework developed by Google, provides advanced human pose estimation capabilities that can detect and track key points on the human body in real-time. By integrating Mediapipe with OpenCV, a versatile library for image and video processing, we aim to create a system that can automatically detect and count bicep curls with high precision. The system captures live video input, identifies relevant body key points, calculates the angles between them to detect curling motions, and updates the repetition count in real-time. By advancing the state of automated exercise monitoring, this research aims to contribute to the development of more sophisticated and user-friendly fitness applications, ultimately supporting individuals in achieving their fitness goals with greater precision and confidence.

# **Related studies**

This paper will detail the methodology employed to achieve these objectives, present the results of our system's performance evaluation, and discuss the implications of our findings for the future of exercise monitoring systems. By automating the counting process and providing real-time feedback, our system aims to enhance the workout experience for fitness enthusiasts and trainers alike, promoting better form and more efficient exercise routines.

## OpenCV

OpenCV is a programming library aimed at real-time computer vision, focusing on real-time image processing. It supports a variety of programming languages, including C++, Python, and Java, and a variety of OS platforms, including Windows, Linux, OS X, Android, and iOS. It can be used for many algorithms, including machine learning, math operations, video capture, and image processing. OpenCV is algorithmically designed to focus on computational efficiency and real-time applications, making it easy to create high-quality commercial programs. It also supports multicore processing, which makes it applicable to a variety of situations.

## MediaPipe

Media Pipe Pose is an ML solution for body pose tracking that uses Blaze Pose research to infer 33 human body key points from RGB video frames. Blaze Pose is a lightweight convolutional neural network architecture. Pose tracking uses a two-stage detector-tracker ML pipeline. First, the pose detector finds a pose ROI (region of interest) within the frame. Next, the pose tracker predicts 33 pose key points from ROI [8]. Applications can be built by applying it to various fields that require posture analysis, such as yoga or fitness.

# **METHODOLOGY**

## Video Capture

# Video capture is the initial stage where the system acquires live video input from a camera. This video feed serves as the fundamental data source for subsequent analysis. OpenCV, a widely-used open-source computer vision library, facilitates this process through its cv2.VideoCapture function. This function enables the system to access the camera hardware, retrieve frames in real-time, and prepare them for further processing. The quality and consistency of the video feed are crucial for the accurate detection and counting of bicep curls stages. For best results, it is recommended that users perform these adjustments in a well-lit environment.

## Pose Estimation

Pose estimation is a critical component that follows video capture. In this stage, the system utilizes Mediapipe, an open-source framework developed by Google, specifically its Pose solution. Mediapipe's Pose solution employs deep learning models to detect and track 33 key points on the human body in real-time. These key points include joints such as shoulders, elbows, wrists, and others relevant to the bicep curl exercise. By accurately estimating the positions of these key points frame by frame, the system establishes a foundational understanding of the user's body posture and movements during exercise.

## Bicep Curl Detection

Bicep curl detection builds upon the pose estimation results to identify and quantify the execution of bicep curls. The system focuses on analyzing the spatial relationships and movements of key points, particularly the shoulder, elbow, and wrist joints. By calculating the angles formed between these joints over successive frames, the system can discern the characteristic motion pattern associated with a bicep curl. This computational approach allows the system to distinguish between intentional bicep curls and other incidental arm movements, ensuring that only valid repetitions are counted. a landmark which is not far from being imperceptible by a camera.

## Counting Mechanism

The counting mechanism is implemented using a state machine approach designed to maintain accurate and reliable repetition counts. This approach tracks the progression of each bicep curl movement cycle based on the detected joint angles. Specifically, it monitors transitions between extended and flexed arm positions indicative of a complete bicep curl repetition. By registering a count only upon detecting a full cycle of motion, the system minimizes the risk of erroneously inflating the count due to partial movements or incidental gestures. This systematic counting mechanism enhances the credibility of performance feedback provided to the user in real-time Calculating the angle between the shoulder, elbow, and wrist in real-time is possible by adding the logic for calculating angles using trigonometry. Real-time angle calculation requires efficient algorithms that can quickly process image or video data and identify the positions of the joints accurately. We have enabled the pipeline to display the angle between the shoulder, elbow, and wrist using the above discussed mechanism over the image real time to verify the accuracy and it is logically acceptable.

## Feedback Display

Real-time feedback is a crucial component of the user experience in the real-time bicep curl detector and counter system. This feedback is provided through visual elements overlaid directly onto the live video feed, utilizing the capabilities of OpenCV, a powerful computer vision library. OpenCV facilitates the integration of graphical elements onto the video stream captured from the camera. Specifically, text elements are dynamically rendered to display relevant information, such as the current count of bicep curl repetitions. This visual feedback mechanism operates in real-time, ensuring that users receive immediate updates on their exercise performance without interruption or delay. The integration of real-time feedback through visual display enhances user engagement and overall experience during exercise sessions. By leveraging OpenCV's capabilities to overlay graphical elements onto the video feed, the system not only provides functional feedback but also enhances user interaction with the technology. This interactive approach fosters a positive user experience, promoting sustained engagement and adherence to fitness routines.

# **Literature review**

##### *Introduction to Computer Vision in Fitness Monitoring*

##### Computer vision has revolutionized various fields, including fitness monitoring, by enabling non-intrusive and real-time tracking of human movements. In fitness applications, the use of computer vision techniques offers advantages over traditional methods such as wearable sensors or manual tracking. These advantages include enhanced accuracy, convenience, and the ability to provide immediate feedback to users during exercise sessions.

*Applications of Pose Estimation in Exercise Monitoring*

Pose estimation, a fundamental component of computer vision, plays a pivotal role in exercise monitoring systems. Research has shown that accurate pose estimation enables systems to detect and track key points on the human body, such as joints and limbs, with high precision. For instance, Mediapipe, an open-source framework developed by Google, has been utilized effectively for real-time pose estimation in various applications, including fitness tracking and gesture recognition.

*Previous Studies on Bicep Curl Detection*

Studies focusing specifically on bicep curl detection using computer vision have highlighted the challenges and advancements in this area. Researchers have explored different methodologies, ranging from angle calculation between key joints to machine learning approaches for pattern recognition. These studies emphasize the importance of robust algorithms capable of distinguishing between different arm movements to accurately count bicep curls.

*Technological Advances and Challenges*

Technological advances in hardware and software have significantly improved the capabilities of computer vision systems for exercise monitoring. For instance, the integration of deep learning models and neural networks has enhanced the accuracy of pose estimation algorithms, making them suitable for real-time applications. However, challenges such as variability in lighting conditions, occlusions, and user-specific movements continue to influence the performance and reliability of these systems.

The impact of real-time feedback on user experience and engagement in fitness monitoring has been extensively studied. Research indicates that visual feedback, such as real-time counts of repetitions overlaid on video feeds, motivates users and enhances their adherence to exercise routines. Furthermore, interactive features that allow users to adjust their workout intensity based on feedback contribute to a more personalized and effective fitness experience.

*Integration of Computer Vision with Fitness Devices*

The integration of computer vision techniques with wearable devices and smart fitness equipment represents a growing trend in the fitness industry. These integrations aim to provide users with comprehensive insights into their exercise performance, including metrics such as form, speed, and intensity. By leveraging real-time data processing capabilities, these systems support users in achieving their fitness goals efficiently and effectively.

The literature review establishes the theoretical and empirical foundation for the development of a real-time bicep curl detector and counter using computer vision techniques. By synthesizing existing research and findings, this section informs the methodology and implementation of the proposed system, highlighting the innovations and challenges within the field of exercise monitoring and computer vision

# **RESULTS AND DISCUSSION**

The implementation of the real-time bicep curl detector and counter system involved integrating computer vision algorithms and techniques to achieve accurate detection and counting of bicep curl repetitions. The system utilized OpenCV for video processing, Mediapipe for pose estimation, and custom algorithms for angle calculation and repetition counting. One of the key findings from the implementation was the accuracy and precision of pose estimation using Mediapipe. The system successfully detected and tracked key points on the human body, including the shoulders, elbows, and wrists, with minimal latency. This capability was crucial for determining the initiation and completion of bicep curl movements.

The system demonstrated effective performance in detecting bicep curls in real-time scenarios. By analyzing the angles between the shoulder, elbow, and wrist joints, the system reliably differentiated between bicep curls and other arm movements. This capability contributed to the accurate counting of bicep curl repetitions during exercise sessions.

The integration of real-time feedback mechanisms significantly enhanced user interaction and engagement during exercise sessions. Visual overlays on the video feed provided users with immediate feedback on their bicep curl performance, including the current count of repetitions. Users reported that this real-time feedback motivated them to maintain proper form and intensity throughout their workouts.

Quantitative metrics, such as detection accuracy and frame processing speed, were evaluated to assess the overall performance of the system. The system achieved an average accuracy in detecting bicep curls, with a processing speed of frames per second (FPS). These metrics underscored the system's reliability and efficiency in real-time exercise monitoring applications.

The performance evaluation of our real-time bicep curl detector and counter system demonstrated robust capabilities in accurately detecting and counting bicep curl repetitions. Comparative analysis with existing methods highlighted several advantages of our approach, particularly in terms of real-time feedback, user engagement, and accuracy. Traditional methods relying on manual counting or sensor-based solutions often lack the immediacy and precision offered by computer vision systems. By leveraging advanced algorithms and pose estimation techniques, our system provided users with actionable insights into their exercise performance, enhancing the overall workout experience.

Despite the promising results, our study identified several challenges that warrant further investigation. Variability in lighting conditions, occlusions of body parts, and individual movement patterns posed constraints on the system's robustness and accuracy. Future research could focus on enhancing algorithm robustness through data augmentation techniques, integrating multimodal sensor inputs for enhanced performance, and optimizing the system for diverse environmental conditions. Additionally, exploring the application of machine learning models for adaptive learning and personalized feedback could further advance the capabilities of real-time exercise monitoring systems.

# **CONCLUSION**

In conclusion, our research successfully implemented and evaluated a real-time bicep curl detector and counter using computer vision techniques. The system demonstrated effective performance in detecting bicep curl movements, providing real-time feedback, and enhancing user engagement during exercise sessions. By leveraging the capabilities of OpenCV and Mediapipe, we developed a robust framework capable of automated repetition counting and performance analysis. The findings from our study contribute to the growing body of research on computer vision applications in fitness monitoring and highlight the potential of technology-driven solutions in promoting active lifestyles and improving exercise outcomes.

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