



# Gym

Gym

March 13, 2024 — Assiut University



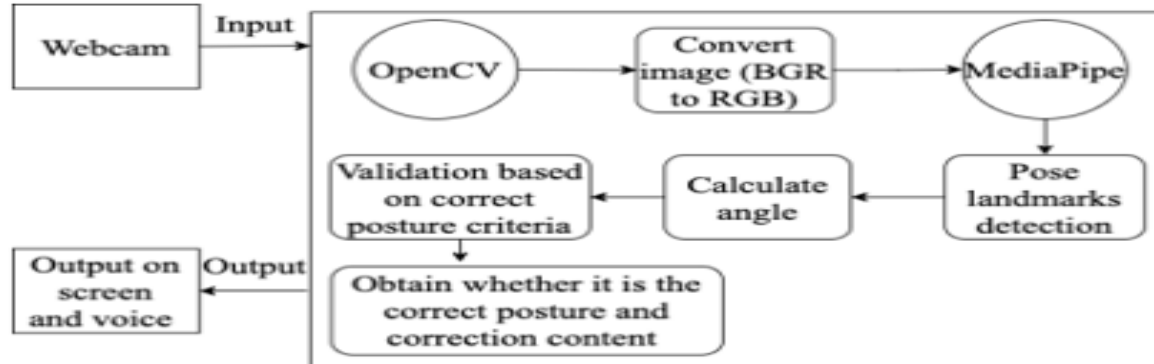
# Introduction

In response to the COVID-19 pandemic and subsequent lockdowns, there has been a surge in interest in digital home exercise programs. While these programs offer convenience, there are risks associated with incorrect posture and lack of professional guidance. It targets people with financial constraints, discomfort in gyms, or scheduling issues, aiming to enhance their exercise experience by assessing repetition quality and quantity. The program utilizes body posture estimation technology, specifically the landmark model of MediaPipe Pose, a machine learning solution, to analyze users' posture in real-time. If the user's posture deviates from correct exercise posture criteria, the program provides on-screen guidance for correction. Conversely, if the posture is correct, the program incrementally counts the number of workouts, providing both visual and auditory feedback to the user. By mimicking the functions of a human gym instructor, this system aims to promote physical activity and combat the negative health effects of sedentary living.

# Methodology

## 1 - Exercise Posture Correction System

The system processes images captured by the webcam and converts them to RGB using OpenCV. The historical model of MediaPipe Pose is then used to detect the body landmarks needed for pose analysis. Postural angles are calculated using the coordinates of these landmarks, and the system determines whether the posture meets pre-defined criteria for correct exercise posture. If not, debugging instructions will be displayed on the screen as shown in Figure 1.



## Definition of Correct Posture:

For squats, correct posture is defined by three conditions: maintaining a hip angle close to 90 degrees, ensuring thighs are nearly horizontal to the floor, and aligning knee and toe lines. The program verifies correct squats based on these conditions:

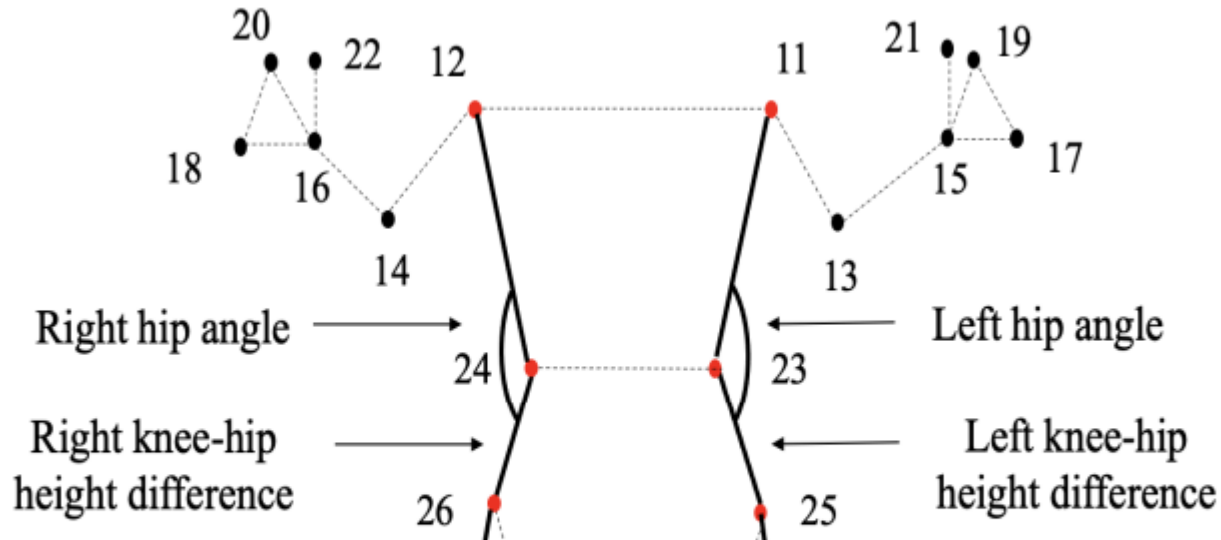
1. Hip angle between 60 and 120 degrees.
2. Minimal difference in y-values between knees and thighs.
3. Slight difference in x-values between knees and toes. Guidance is provided for correction based on these conditions.

Push-up correctness is determined by:

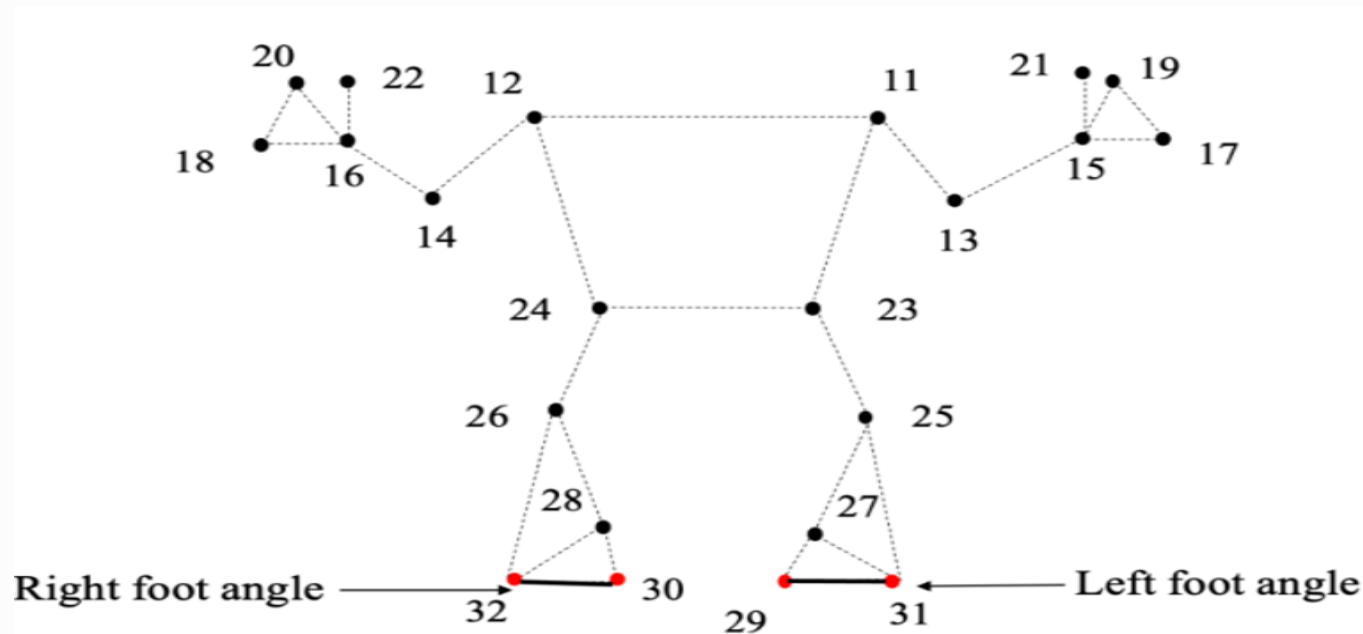
1. Elbow angle between 70 and 100 degrees.
2. Body angle between 160 and 200 degrees..

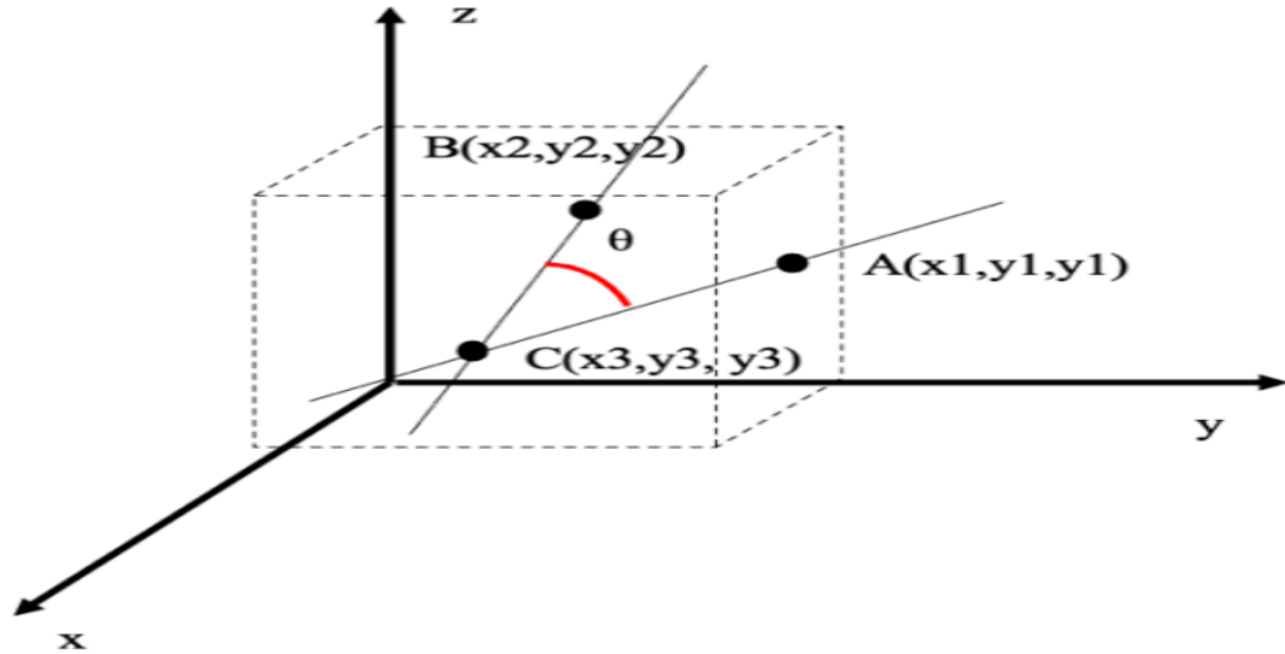
## 2 - Pose Landmark:

Key points from the MediaPipe landmark model are used to validate correct posture conditions. For instance, in squats, angles between various body parts are calculated to ensure correct posture as shown in Figure 3.



from the heel to the toe tip. To accommodate foot angle variations, the rotation angle is averaged across both feet. Figure 7 illustrates the key points used to calculate the foot angle. For the left foot, the key points are the left heel and left foot, while for the right foot, they are the right heel and right foot.





**Figure 5.** Angle between three points.

### 3 - Smart Gym Trainer using Human Pose Estimation:

obtaining pre-trained model weights, processing input videos for pose estimation, generating skeletal structures and angles, and creating graphs for exercise form comparison. Limitations include lack of exercise-specific implementation, absence of a repetition counter mechanism, and no progress bar for tracking exercise duration. The system employs a two-step detector-tracker machine learning pipeline to ensure accurate pose detection.

### 4 - Survey on Gym-Goer Behavior by Better:

Primary reasons for not attending the gym include a shortage of time and lack of confidence. Male gym-goers tend to spend more on memberships compared to females.



## 5 - Virtual Gym Instructor:

The system stores details about exercises, including trainer information and controller settings. Algorithms like Gaussian Blurring, Histogram Equalization, Background Subtraction, Haar feature-based cascade classifier, and others are implemented to optimize performance. Body parts are traced using the TraceBodyObject algorithm. Trainer data is stored as training data, while user data is processed in real-time for comparison as shown in figure 6.

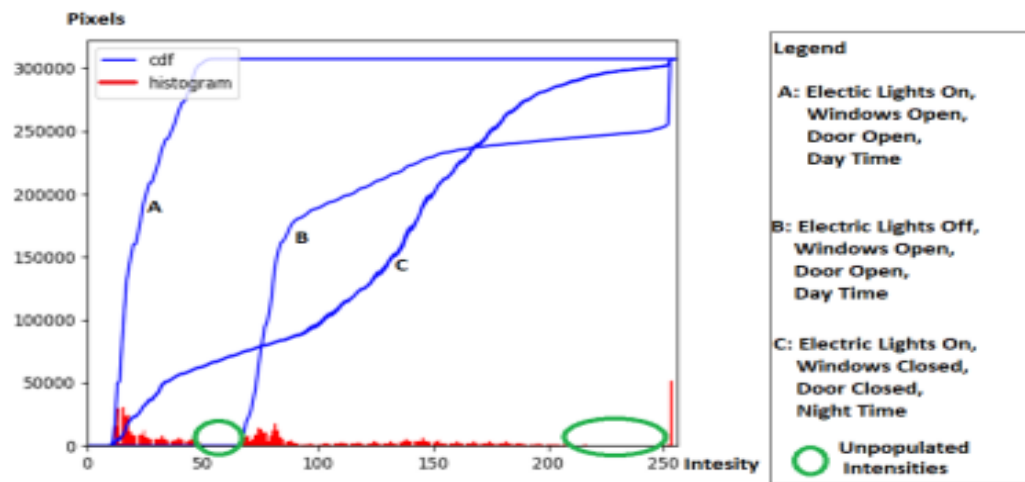


**Figure 6. Virtual Gym Instructor Decomposition Tree**

Figure:

## 6 - Histogram Equalization:

Used to normalize pixel intensity distribution over various lighting settings. Improves feature detection and segmentation by equalizing intensity histograms as shown in Figure 7.



**Figure 7.** Different Lighting Frame Pixel Intensity Graph

## Results

the program's output for both correct and incorrect postures for squats and push-ups. In Figure 8, the program output confirms correct squat posture, characterized by a hip angle between 60 and 120 degrees, thighs positioned near the floor, and knees not crossing the toe line. When these conditions are met, the screen displays an increased workout count, with the number also verbally announced.



In Figure 9, the program output indicates incorrect squat posture, as the thigh is not maintained horizontally with the floor. Consequently, a guideline is displayed to correct this, and the exercise count remains unchanged.



**Figure 9.** Incorrect squat posture.

In Figure 10, the program output indicates an incorrect push-up posture, as the elbow angle exceeds 100 degrees. Consequently, a guideline is displayed to bend the arm more to approximately 90 degrees, and the exercise count remains unchanged.



**Figure 10.** Incorrect push-up posture.

In Figure 11 demonstrates the correct user posture during push-ups. A proper posture requires an elbow angle between 70 and 100 degrees, with the body angle close to 180 degrees. In this posture, guidelines are not displayed, and the exercise count increases. Additionally, the number of workouts number is verbally output.



**Figure 11.** Correct push-up posture.

Screenshots demonstrate how the system displays correction messages or workout counts. An experiment is conducted to evaluate the program's success rate in counting exercises performed with correct posture. The success rate formula is provided. In Table1 summarizes the experimental results (presumably showing high success rates).

Number of workouts	Squat success rate	Pushup success rate
1	100%	100%
2	100%	100%
3	100%	67%
4	100%	75%
5	100%	80%

**Table 1.** Calculation success rate



The provided figure showcases the live camera feed displaying the user during a curl exercise, indicating the number of reps completed and offering guidance for subsequent steps. Additionally, a video on the right side of the figure demonstrates proper techniques and postures to enhance or perform the exercise correctly.





The Virtual Gym Instructor system has been tested extensively to evaluate its performance and effectiveness. Results show that the system can accurately track users' movements in real-time and provide meaningful feedback during workouts.



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