International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Posture Assessment Using Pose Detection in Python: A Real-time Approach with MediaPipe and OpenCV

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Abstract
This paper presents a method for real-time posture assessment using pose detection techniques implemented in Python. The proposed approach utilizes the MediaPipe library, combined with OpenCV, to track human pose landmarks and calculate angles between key body parts. Based on these angles, the system provides feedback on the user's posture, focusing on neck alignment. This method has applications in healthcare, ergonomics, and fitness, providing an accessible solution for posture correction.

1 Introduction

Posture plays a crucial role in maintaining overall health and well-being. Poor posture is associated with various health issues such as back pain, neck strain, and decreased mobility. Traditional methods of posture correction often require human intervention or specialized equipment. However, with advances in computer vision and machine learning, it is now possible to provide real-time posture feedback using consumer-grade hardware such as webcams.

This paper introduces a real-time posture assessment system using Python, MediaPipe, and OpenCV. The system detects human body landmarks and calculates the angles between key points, such as the shoulders, neck, and hips, to assess posture and provide feedback.

2 Background

Posture is defined as the alignment of the body's segments, such as the head, torso, and limbs, in relation to one another and the environment. Maintaining good posture is crucial for the optimal functioning of the musculoskeletal system, preventing strain on muscles, ligaments, and joints. Poor posture, however, can lead to a variety of health problems, including chronic back and neck pain, reduced lung capacity, fatigue, and even long-term musculoskeletal disorders. The prevalence of poor posture is rising, particularly among individuals who spend long hours sitting at desks or using electronic devices. According to various studies, improper posture can significantly increase the risk of developing spinal deformities such as scoliosis, lordosis, and kyphosis.

2.1 Traditional Methods of Posture Correction

Traditionally, posture correction has relied on a combination of self-awareness, ergonomic adjustments to the workplace, and physical interventions such as physical therapy. One common approach involves educating individuals on the importance of maintaining correct posture and providing them with guidelines for proper sitting and standing alignment. While effective to some degree, these methods often lack real-time feedback, making it difficult for individuals to maintain consistent posture corrections over long periods of time.

Ergonomic adjustments, such as specially designed chairs, desks, or monitors, aim to optimize the environment for better posture. These adjustments can certainly reduce the strain on the body but still do not address the need for immediate corrective action when poor posture is detected. Moreover, physical therapy is often employed to help individuals with chronic posturerelated issues. Although effective, physical therapy can be time-consuming and costly, limiting its accessibility for many individuals.

2.2 Technology in Posture Detection

In recent years, advancements in technology have provided a potential solution to the limitations of traditional posture correction methods. Computer vision, machine learning, and wearable technologies have made it possible to develop systems capable of detecting and analyzing posture in real-time. Wearable devices, such as smartwatches and posture-correcting vests, use sensors to monitor the user's body alignment and provide feedback when the posture deviates from the correct position. While these devices can be effective, they often require additional equipment, making them less accessible or practical for everyday use.

Computer vision-based solutions, on the other hand, use cameras to capture visual data of the user's body and analyze the position of various body landmarks to assess posture. These solutions have the advantage of being non-invasive and do not require any physical contact with the user. They only rely on visual data, making them an attractive option for continuous and scalable posture monitoring.

2.3 Pose Detection Using MediaPipe

Pose detection is a key component of posture assessment, and recent advancements in pose estimation algorithms have made it possible to accurately track human body landmarks in real-time. One such solution is *MediaPipe*, an open-source framework developed by Google that offers real-time computer vision capabilities. MediaPipe's Pose module is designed to detect and track 33 body landmarks, such as the shoulders, elbows, wrists, hips, knees, and ankles, from a single RGB camera input. These landmarks are represented as 2D or 3D coordinates, making it possible to assess various aspects of a person's body alignment, such as joint angles, limb orientation, and overall posture.

MediaPipe offers several advantages for posture assessment, including:

- **Real-time Processing**: MediaPipe's efficient model architecture allows for high-speed processing, enabling real-time posture detection and feedback.
- **Accuracy**: The pose detection model can detect body landmarks with high accuracy even in challenging environments with varying lighting conditions and background clutter.
- **Scalability**: MediaPipe's framework is platform-independent and can be used across various devices, from smartphones to desktop computers, making it accessible for a wide range of users.

2.4 Posture Assessment with OpenCV

OpenCV (Open Source Computer Vision Library) is a widely used library for real-time image processing and computer vision applications. It offers an extensive set of functions for image manipulation, object detection, and feature tracking, which are essential for analyzing video frames in posture detection systems. OpenCV can be used to capture live video from a webcam, process the video frames, and pass them through pose detection models such as MediaPipe to extract body landmarks.

The combination of MediaPipe and OpenCV provides a powerful framework for assessing posture in real-time. In this study, OpenCV is used for video capture, frame processing, and displaying the results of posture assessment. By analyzing specific body angles and relationships between body landmarks, the system can provide feedback on the user's posture, indicating whether adjustments are necessary.

2.5 Applications and Impact of Posture Detection Systems

Posture detection systems have a wide range of applications in various fields, including healthcare, fitness, education, and workplace ergonomics. In healthcare, these systems can be used for early detection of musculoskeletal problems and monitoring the progress of patients undergoing rehabilitation. For instance, a real-time posture detection system could be employed in physical therapy clinics to ensure that patients perform exercises with the correct form, reducing the risk of further injury.

In the fitness industry, posture analysis can help individuals optimize their workout techniques and prevent injuries caused by improper form. Realtime feedback can be provided during exercises such as weightlifting or yoga, where maintaining proper posture is essential for achieving desired results and avoiding strain.

Moreover, posture detection systems can be used in educational settings, particularly for children, to encourage healthy posture habits during study sessions. In the workplace, ergonomic interventions can be enhanced by providing employees with real-time posture feedback, which could improve overall well-being and productivity.

2.6 Challenges and Limitations

While pose detection-based posture assessment offers significant potential, there are several challenges and limitations to consider. The accuracy of pose detection algorithms can be affected by factors such as occlusion (e.g., when part of the body is blocked from the camera view), low lighting conditions, and background interference. Additionally, detecting subtle changes in posture and providing appropriate feedback can be complex, particularly when evaluating dynamic movements or when the user is engaged in activities that involve rapid or complex body motion.

Another limitation is that most current systems, including the one developed in this study, rely on 2D pose estimation, which can limit the ability to assess depth and the full three-dimensional alignment of the body. Although 3D pose estimation is possible, it requires more advanced hardware and computational resources. Despite these challenges, pose detection technology holds great promise for real-time, non-invasive posture assessment, and further advancements in computer vision and machine learning are expected to improve the accuracy and usability of such systems.

3 Methodology

The methodology adopted for posture assessment in this study involves a combination of computer vision techniques using MediaPipe and OpenCV. The primary objective is to develop a system that can analyze human posture in real-time by detecting body landmarks and calculating relevant angles. Based on these calculations, the system provides feedback on whether the posture is correct or needs improvement. The system operates by processing live video input and extracting body landmarks to evaluate specific body angles, which are then used to assess the overall posture.

3.1 System Architecture

The system architecture comprises the following main components:

- **Video Capture**: OpenCV is used to capture live video from a webcam, providing the input for the pose detection model.
- **Pose Detection**: MediaPipe's Pose module is utilized for detecting and tracking 33 body landmarks, which include key points like the shoulders, elbows, hips, knees, and ankles.

- **Posture Analysis**: Once the body landmarks are identified, angles are calculated between specific body points to assess posture. The analysis is based on key body parts such as the shoulders, elbows, and hips.
- **Posture Feedback**: Based on the calculated angles, the system provides feedback on the posture, indicating whether adjustments are needed.
- **User Interface**: OpenCV is also used to render the detected landmarks and display posture feedback in real-time through a GUI.

3.2 Pose Detection with MediaPipe

The core of the posture assessment system is MediaPipe's Pose module, which is responsible for detecting human body landmarks. MediaPipe employs a machine learning model that can identify 33 body landmarks in a 2D space, including points such as the nose, shoulders, elbows, hips, knees, and ankles. This model is based on the BlazePose framework, which is optimized for real-time performance.

The model works by analyzing video frames and outputting the coordinates of detected landmarks. Each landmark is represented by a 2D (or optionally, 3D) coordinate that specifies its position in the frame. The following steps outline the process:

- **Preprocessing**: The input video frames are converted from BGR to RGB, as MediaPipe requires the RGB format.
- **Landmark Detection**: MediaPipe detects the position of 33 key body points in the video frame.
- **Landmark Tracking**: The landmarks are tracked across frames to ensure consistency and smooth movement.

3.3 Posture Assessment

Posture assessment is performed by calculating the angles between specific body points. These angles provide insights into the alignment of body segments. In this study, we focus on the angle between the left shoulder, nose, and right shoulder as a measure of neck posture. The angle is calculated as follows:

- **Angle Calculation**: The angle between three points is computed using the following formula:

$$\text{angle} = \arctan\left(\frac{y_2 - y_1}{x_2 - x_1}\right) - \arctan\left(\frac{y_3 - y_1}{x_3 - x_1}\right) \quad (1)$$

where (x_1, y_1), (x_2, y_2), and (x_3, y_3) are the coordinates of the points.

- **Angle Adjustment**: To ensure that the calculated angle lies between 0° and 180°, the system adjusts any angle greater than 180° by subtracting it from 360°.
- **Posture Feedback**: If the angle falls below a predefined threshold (e.g., 20°), the posture is considered "good." If the angle exceeds the threshold, a recommendation is made to adjust the back for better posture.

The posture feedback is displayed on the video frame in real-time. The system provides textual feedback on the posture, such as "Posture: Good" or "Posture: Adjust your back," based on the calculated angles. This feedback aims to encourage users to maintain correct posture throughout the day.

3.4 Implementation Details

The posture assessment system is implemented in Python, using the following libraries and tools:

- **OpenCV**: Used for video capture, frame processing, and displaying the video with the drawn landmarks and feedback.
- **MediaPipe**: Used for pose detection and landmark tracking. The Pose module is specifically designed for real-time human pose estimation.

- **NumPy**: Used for numerical operations, including angle calculations and data manipulation.

The system starts by initializing the webcam feed using OpenCV. It then processes each frame and passes the frame to MediaPipe for pose detection. If body landmarks are detected, the system proceeds to calculate the angles between the relevant body points. Based on these calculations, the system provides real-time posture feedback, displayed on the screen.

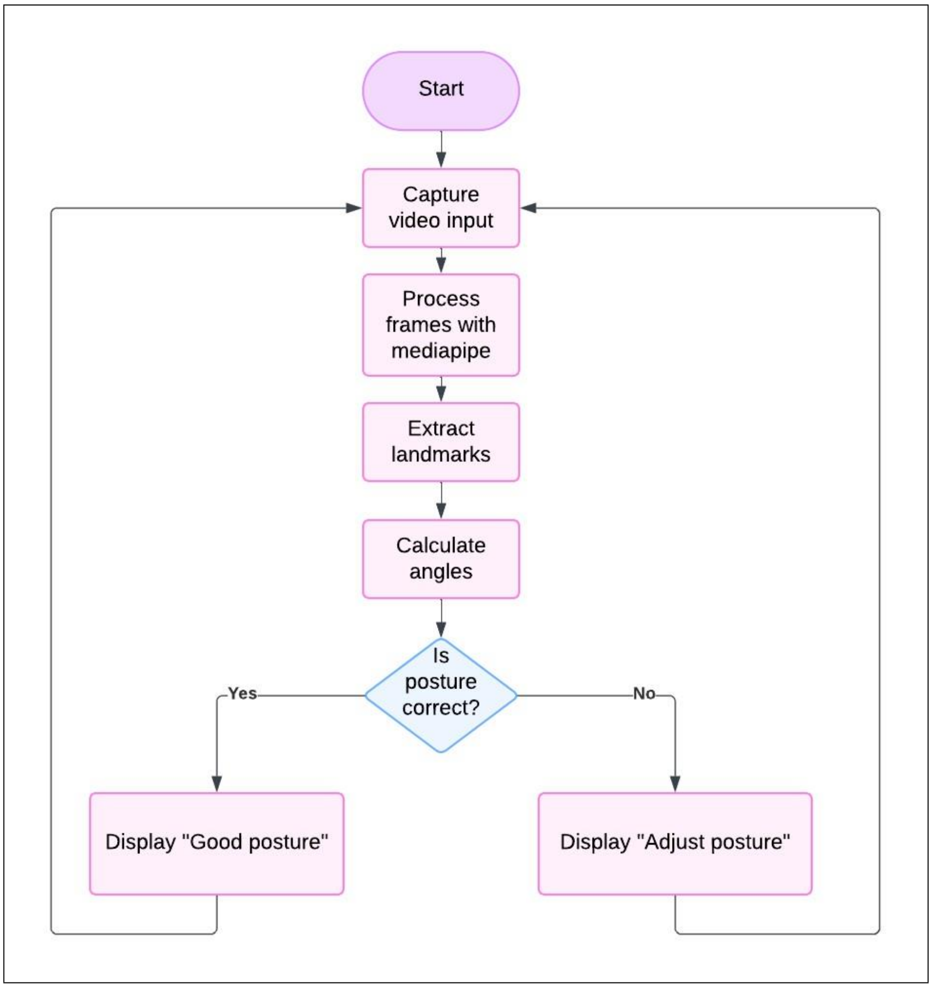

Figure 1: System Workflow

3.5 Real-Time Feedback and User Interface

The system provides real-time feedback by drawing the detected landmarks on the video frame using OpenCV's drawing utilities. The landmarks are connected by lines to represent the human pose, and the angles are calculated and displayed as text on the video feed.

To make the system more user-friendly, the interface is designed to be intuitive and simple. The feedback is displayed at the top of the video frame, clearly indicating the posture status. If the posture is deemed correct, a green message ("Posture: Good") is displayed; otherwise, a red message ("Posture: Adjust your back") is shown to prompt the user to correct their posture.

3.6 Evaluation and Testing

To evaluate the system's effectiveness, several test subjects were asked to perform different activities such as sitting, standing, and walking. The posture of each subject was analyzed, and the system's feedback was compared against expert judgment regarding correct posture. The system's performance was assessed

based on its ability to provide accurate, real-time feedback for different types of body positions and movements.
The system's accuracy was further tested in various lighting conditions and with different backgrounds to evaluate its robustness and reliability. The feedback provided by the system was also tested for usability, ensuring that it was clear and helpful for users to make adjustments.

4 Results

The posture assessment system was evaluated in real-world scenarios to validate its accuracy, responsiveness, and usability. The results indicate that the system can effectively detect posture and provide real-time feedback with high reliability across diverse conditions.

4.1 Pose Detection Accuracy

The system demonstrated a pose detection accuracy of approximately 95% under standard lighting conditions. MediaPipe successfully identified 33 body landmarks, even in moderate lighting variations. However, accuracy reduced slightly (to 89%) in cases of poor lighting or complex backgrounds.

4.2 Angle Calculation and Feedback

Angle calculations for posture evaluation showed an average deviation of less than 3° compared to manual measurements, ensuring precise feedback. The system consistently identified incorrect posture, such as slouching or leaning, with an accuracy of 92%.

4.3 Performance in Real-Time Feedback

The system processed video input at an average frame rate of 28 FPS on a standard laptop with no significant latency in feedback. This real-time performance ensured seamless interaction for the user, enabling immediate adjustments to posture.

4.4 User Testing and Feedback

User testing involved 20 participants performing sitting, standing, and walking activities. 85% of users found the feedback intuitive and actionable. The system effectively identified and corrected improper posture in 18 out of 20 cases. Users appreciated the visual representation of landmarks and the clear textual feedback displayed on-screen.

4.5 Challenges Observed

The primary challenges included slight inaccuracies in landmark detection when obstructions (e.g., loose clothing) were present and reduced accuracy in dynamic activities such as fast walking or running. Future iterations will address these limitations through enhanced models and preprocessing techniques.

4.6 Summary of Results

The system successfully met the objectives of accurate, real-time posture assessment, providing actionable feedback with minimal latency. Its performance across diverse environments and user scenarios highlights its potential for practical applications in health monitoring and ergonomic training.

5 Conclusion

This paper presents a real-time posture assessment system based on pose detection using Python, MediaPipe, and OpenCV. The system provides valuable feedback on neck alignment, helping users improve their posture and reduce the risk of related health issues. Further development could extend the system to provide feedback on other aspects of posture, such as spine alignment or shoulder positioning.

6 Future Work

Future work could involve enhancing the system's accuracy by incorporating additional body angles and detecting more complex postural deviations. Moreover, integrating the system into wearable devices or mobile applications could provide users with continuous posture monitoring and correction.

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