Developing a Body Posture Detection for Fitness

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Abstract

The Body Posture Detection System for Fitness is an innovative technology that aims to enhance exercise technique and movement patterns by providing real-time monitoring and feedback. It utilizes computer vision and machine learning algorithms to track and analyze body movements during fitness. The system's ability to provide immediate feedback and correction significantly improves exercise effectiveness and user safety. It also comes with the user-friendliness of the system, potentially incorporating a Graphical User Interface (GUI) for easy navigation and accessibility. To address time and budget constraints, the approach of this research will choose the Rapid Application Development (RAD) Model as the system development approach. This methodology consists of four phases which are: requirement planning, user design, rapid construction, and transition, and each is accompanied by deliverables. These efforts are aimed at enhancing the functionality and usability of the Body Posture Detection System for Fitness while addressing user needs and optimizing fitness training experiences.

Keywords: OpenCV, Tkinter, Body Posture Detection, Graphical User Interface

1. Introduction

Body Posture Detection is a system that for user can maintaining their body posture during fitness. It is an Artificial Intelligent technology and computer vision that are able to detecting and understanding the position and structure of human body parts from user input. With the Artificial Intelligent and Computer Vision techniques it owns the ability like a human to “see” and understand the visual information but it has the ability to generate an appropriate output based on it understanding [1]. This Technology are able to do a wide range of task such as image classification by assigning a label or category to an image, image localization by identifying and locating multiple objects in an image, image segmentation by partitioning an image, and key-point detection by identifying specific points or landmarks in an image [12]. So, with these technologies it greatly helps a lot in the industry of Object detection, facial recognition, hand gesture recognition, body posture detection, and so on [1], [13]. In this project, Body Posture Detection for Fitness is greatly suitable for using these technologies for detecting those joint parts.

In the worlds nowadays, Fitness become a popular exercise for people, this exercise it brings a lot of benefits such as reducing the risk of cardiovascular disease and metabolic syndrome, controlling weight, strengthening bones and muscles, and promoting mental health. Doing exercise is important but without a proper posture then it will be dangerous, because incorrect posture of exercise during fitness will lead to serious of injuries in the part of muscle and ligaments [2]. Then, it is importance to own a personal trainer during fitness, he or she can oversee your workout session and monitor your posture is proper or not, but unfortunately not everyone is able to hire a personal trainer or guidance due to many reasons such as financial issue, social distance issue, and more.

So, with this situation the Artificial Intelligent based application will become an important role in identifying the user posture during fitness and giving the instant feedback to help the user improve their body posture during fitness. Also, with the power of Artificial Intelligence and Computer Vision, the user is able to know the correct posture during fitness by the real-time guidance and help improving exercise safety and effectiveness (Fig. 1).

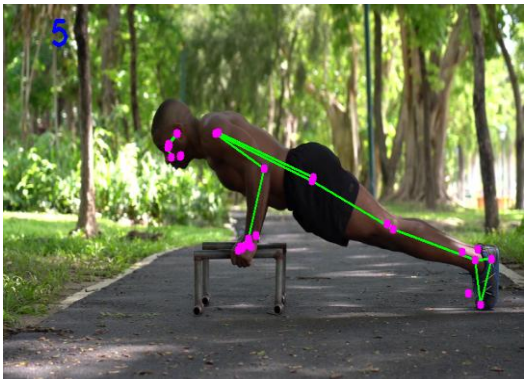

Fig. 1. Body Posture Detection

2. Literature Review

2.1. Comparison of Body Posture Detection Systems

A comparison of different methodologies in various body posture detection systems are shown in Table 1.

Table 1. Comparison of Body Posture Detection Systems

Paper Name (Publication Year)	Techniques	Advantages
Smart exercise counter using computer vision [3] - 2022	OepnCV, MediaPipe	Good Accuracy: Computer vision and Artificial Intelligence algorithms, the system can accurately detect the joint of body and count exercises, ensuring precise monitoring of fitness activities.
Body Posture Detection and Motion Tracking using AI for Medical Exercises and Recommendation System [4] - 2022	MediaPiPe Django	More Accurate compare to the others object detection model: MobileNetV2-SSD: 97.95% MediaPipe: 98.61%
A wearable-based posture recognition system with AI-assisted approach for healthcare IoT [5] - 2022	Multi-Posture Recognition (MPR) Cascade-AdaBoosting-CART (CACT)	High Accuracy and Reliability: The WMHPR system, with its combination of MPR and CACT posture recognition algorithms, achieves a high level of accuracy (98.06% True Positive Rate) and reliability (0.19% False Positive Rate). This is a significant advantage in healthcare applications, ensuring accurate recognition of human postures.
A Survey on Artificial Intelligence in Posture Recognition [6] - 2023	Sensor-Based Recognition Vision-Based Recognition RF-Based Recognition	Sensor-based recognition is cost-effective but requires sensor wear in real-time. Vision-based recognition is highly accurate but affected by lighting, background, and privacy concerns. RF-based recognition is contactless and sensitive to environmental changes but can be influenced by how the human body interacts with RF signals.

2.2. Approach of Body Posture Detection

To develop a body posture detection, recognition, or classification system, it required a Recognition Approaches. This Recognition Approaches is allowing the system to capture or collect the data of body movements. So, in these studies we have found the main approaches of recognition which is Vision-Based.

Vision-based methods for body posture recognition utilize visual information, typically derived from images or video frames, to analyze and interpret body postures. These techniques employ computer vision to extract pertinent features from the visual data, facilitating the recognition and understanding of human body poses. Here are some techniques based on vision-based methods in body posture recognition:

- Image Processing and Analysis: Vision-based methods often commence with image processing techniques to detect and extract significant features from the images. This could include identifying key body joints, angles between joints, and the overall configuration of the human body [7].
- Skeletonization Techniques: Vision-based methods may use skeletonization techniques to represent the human body as a simplified skeleton, emphasizing key joints and connections. This skeletonized representation facilitates the recognition of different body postures [8].

In conclusion, vision-based methods offer a powerful and versatile approach to body posture recognition, leveraging the rich visual information available in images or video frames for accurate and real-time analysis of human poses.

2.3. The Study of Proper Posture in Fitness

The posture you maintain while performing exercises plays a crucial role in determining the effectiveness of your workout and preventing injuries while fitness. So,

there are some of the correct postures for some common exercises such as push-ups, sit-ups, and dumbbell lifting.

Push-ups are a foundational movement in strength training. However, they are often performed incorrectly. The tips are, first, set your hands at a distance slightly wider than shoulder-width apart on the ground. Second, your hands should be angled in a way that feels comfortable to you. Your feet should be set up in a way that feels right and comfortable and in balance. Third, your body should form one giant straight line from the top of your head down through your heels. Last, your butt shouldn't be sticking way up in the air or sagging [9].

Sit-ups is one of the exercises to strengthening your core. The tips are, first, lie on your back, with knees bent and feet firmly on the ground. Second, place your hands behind your head, or place each hand on the opposite shoulder, so arms cross over the front of your body. Last, slowly lift your upper body off the ground, keeping your chin tucked into your chest as you do so [10].

Dumbbell lifting is a great way to build muscle and improve strength. The tips are, first, warm up your body before you start lifting. Second, choose the right weight for you. Too much weight will only give you fewer sets before tiring out while too lightweight dumbbells won't target your muscles enough. Third, lift slowly, you want to feel the weight of the dumbbell as you lift it up and down and make your muscles work with the utmost time. Last, cool down once you're done with your workout [11].

3. Analysis

The survey has collected a lot of useful data and allows us to understand the preferences of those who took part in the survey for gathering information about the Body Posture Detection System for Fitness. Also, the most of participants are young adults aged between 18 and 25. The participants are in different races, most of them are come from Chinese, and from various university backgrounds.

Moreover, most of the participants during fitness are doing different poses, the most common usually are such as weightlifting, squatting, and push-ups. Also, the aim of the fitness goals of these participants is intend to weight loss and muscle gain.

After that, participants also noticed the negative effects of incorrect postures, such as bringing some downsides like muscle strain and joint problems. So, there is a positive attitude toward the use of a Body Posture Detection System, suggesting a potential interest in using technology to improve workout safety and effectiveness.

Also, participants have mentioned the specific features of the system should consist of real-time monitoring, accuracy, user-friendly interfaces, and educational resources. Most participants support the idea of integrating body posture detection into their fitness routines, particularly at home. The strong demand for educational resources within the system reflects the participants' dedication to learning and enhancing their fitness skills.

4. Synthesis

The figure below (Fig. 2) shown the use cases of the Body Posture Detection System for Fitness. This system used to detect the body movement and body posture of user. So, in this situation the system first will detect the user body key point through the algorithm and allow the algorithm work with the camera. After that, the computer vision is able to see people through camera, and starting to detect the body posture/movement of the user. Then it will estimate the body posture of the user by using key point, after that it will check the body posture that user perform is correct or not. Last, it will display the result.

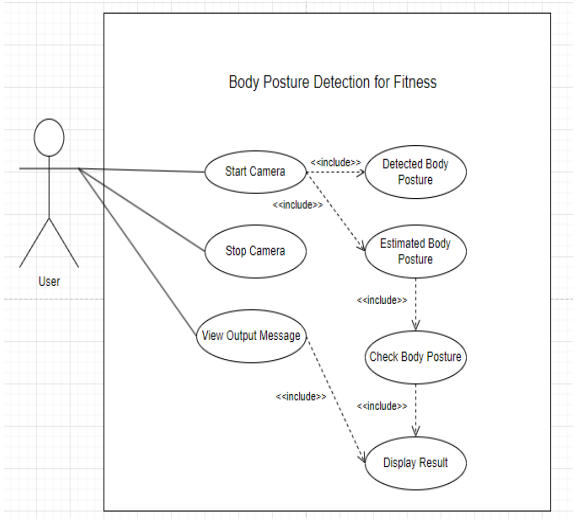

Fig. 2. Use Case Diagram of Body Posture Detection System

5. Evaluation

5.1. Proposed Method

This system is used to detect and calculate different types of exercises such as squats, push-ups, and weightlifting. Below are the main components of this program:

- App Class: This is the main class of the system which use to run the GUI and pose estimation. It initializes the application, sets up the GUI layout with buttons and labels, and initializes variables used for pose estimation and exercise counting.
- MyVideoCapture Class: This class is used to capture video the web camera. It has methods to get the current frame and release the video source when it is no longer needed.

- Update methods: The update_pose_estimation, update_squat_estimation, update pushUp_ estimation and update_lift_estimation methods in the App class are used to update the GUI with the current frame and pose estimation results from the video source. These methods are called repeatedly after a certain delay to provide real-time pose estimation.

These methods work together to create a dynamic fitness application that uses pose estimation to detect the user's posture in each frame of the video, calculates joint angles to determine the posture, and computes the number of exercises based on changes in posture. The results are displayed in the GUI, allowing the user to start and stop posture estimation and select the type of exercise.

6. Conclusion

All in all, the development of Body Posture Detection for Fitness with Python has successfully been developed. This system was developed with Python and its libraries such as cv2 library, mediapipe library, tkinter library. Users expressed interest in features like real-time monitoring, accuracy, user-friendly interfaces, and educational resources, showing a strong demand for integrating such a system into their fitness routines, especially at home.

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