[P-1]

A PROJECT BASED LEARNING-II REPORT ON

Virtual trAIner

SUBMITTED TO THE SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE IN THE FULFILLMENT OF THE PBL-II TW

SECOND YEAR OF COMPUTER ENGINEERING

SUBMITTED BY

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CERTIFICATE

This is to certify that the SPPU Curriculum-based Project Based Learning-II report entitled

Virtual trAIner
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has satisfactorily completed the curriculum-based Project Based Learning-II under the guidance of Prof. Madhuri Wakode towards the fulfillment of second year Computer Engineering Semester IV, Academic Year 2022-23 of Savitribai Phule Pune University.

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Place:
Date :

ACKNOWLEDGEMENT

It gives us great pleasure in presenting the PBL-II report on “Virtual trAIner”.

First of all, we would like to take this opportunity to thank my PBL-II guide Prof. Madhuri Wakode ma’am for giving us all the help and guidance needed. We are grateful for her kind support and valuable suggestions that proved to be beneficial in the overall completion of this PBL-II work.

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CV – Computer Vision

UI – User Interface

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1. Introduction

Exercise correctness is crucial for ensuring maximum benefit and minimizing the risk of injury during physical workouts. Traditional methods of monitoring exercise correctness involve manual observation by fitness trainers or subjective self-assessment. This project aimed to automate this process using CV techniques to provide objective and real-time feedback on exercise performance.

1.1 Motivation

Objective Assessment: Traditional methods of assessing exercise correctness rely on subjective observations by fitness trainers or self-assessment by individuals. These methods can be prone to bias and human error. By implementing a CV system, objective and consistent feedback can be provided, ensuring accurate assessment of exercise performance.

Remote Exercise Monitoring: With the rise of remote and online fitness programs, there is a need for effective exercise monitoring outside traditional gym settings. CV-based systems can enable trainers or instructors to remotely assess exercise correctness, provide personalized feedback, and ensure proper form, regardless of the user's location

Injury Prevention: Incorrect exercise technique increases the risk of injuries. By detecting and alerting individuals about improper movements, a CV system can play a crucial role in injury prevention. This can be especially beneficial for beginners or individuals without access to professional trainers.

Personalized Coaching: A CV system can analyze exercise performance on an individual level, providing personalized feedback tailored to each person's specific needs. This personalized coaching can help individuals progress in their fitness journeys, address weaknesses or imbalances, and achieve optimal results.

Scalability and Accessibility: Once developed, a CV-based exercise correctness detection system can be easily deployed and scaled, making it accessible to a wide range of users. It has the potential to be integrated into mobile applications, fitness equipment, or online platforms, democratizing exercise monitoring and feedback.

1.2 Problem Statement/ Objective :

1. Implement a CV system that can process real-time exercise videos captured from a webcam or video input source.

2. Provide real-time feedback on exercise correctness based on the classification results from the trained model.
3. Explore potential applications of the CV-based exercise correctness detection system, such as remote exercise monitoring, personalized fitness coaching, or integration with fitness-related platforms or devices.

2. Literature Survey

1."Computer Vision Techniques for Human Pose Estimation in Exercise Analysis: A Survey" by S. Gupta and R. Sharma (2019)

This survey paper provides an introduction to computer vision techniques for human pose estimation in exercise analysis. It explains the basics of pose estimation algorithms, such as keypoint detection and skeletal tracking, and discusses their application in exercise correctness detection. The paper also provides an overview of common datasets and evaluation metrics used in this field.

2."Exercise Analysis Using Computer Vision: A Review of Methods and Applications" by M. Patel and N. Shah (2018)

This review paper offers a beginner-friendly overview of exercise analysis using computer vision. It explains the fundamental concepts of computer vision, such as image processing and feature extraction, and how they can be applied to analyze exercise correctness. The paper covers basic techniques, challenges, and potential applications in the field.

3."Computer Vision-Based Exercise Monitoring: An Introduction" by A. Johnson and C. Thompson (2020)

This introductory article provides a beginner-friendly overview of computer vision-based exercise monitoring. It explains the basic principles of computer vision and how they can be used to monitor and assess exercise correctness. The paper also discusses the potential benefits and limitations of using computer vision in this context.

3. Software Requirements Specifications

Exercise correctness detection aims to develop a system that utilizes computer vision techniques to analyze exercise videos and provide feedback on the accuracy of exercise performance. By leveraging computer vision algorithms, such as pose estimation and motion analysis, the system can identify and track key body movements during exercises. It then compares these movements against predefined correct exercise patterns to determine the correctness of each repetition or movement. The feedback provided by the system enables users, such as fitness enthusiasts or trainers, to adjust and improve their exercise techniques, leading to safer and more effective workouts. The software requirements for such a project would be as follows:

3.1 Project Scope

Evaluation and Performance Metrics: The developed CV system will be evaluated using a separate test dataset that was not seen during training. Performance metrics such as accuracy, precision, recall, and F1-score will be calculated to assess the system's effectiveness in exercise correctness detection.

Potential Applications: The project may explore the potential applications of the CV-based exercise correctness detection system. This could include remote exercise monitoring, personalized fitness coaching, integration with mobile applications or fitness equipment, or incorporation into online fitness platforms.

3.2 SDLC Model

For developing this project on exercise correctness detection within a three-month timeframe, our SDLC Model of choice was the Agile model. Agile is an iterative and incremental approach that emphasizes flexibility, collaboration, and rapid delivery of working software.

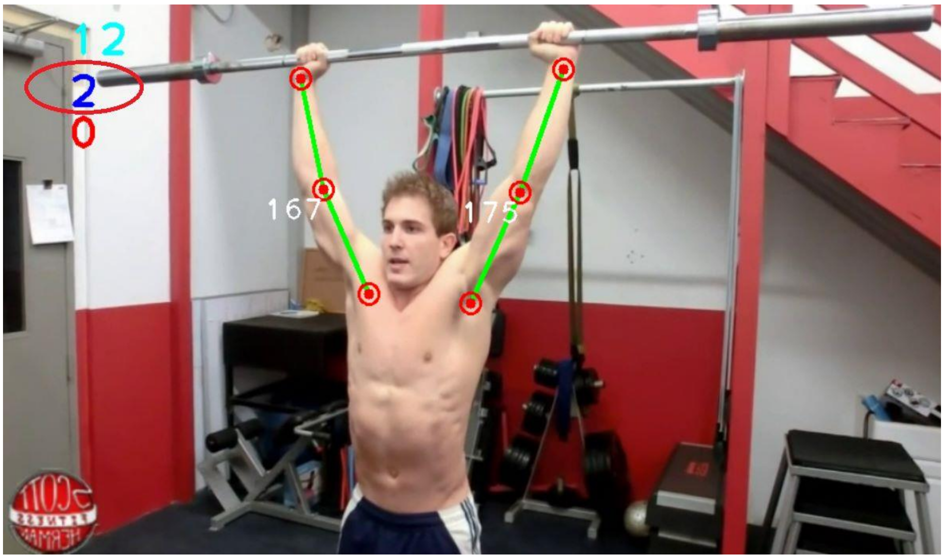
3.3 Functional Requirements

The functional requirements of this project involve the core functionalities and capabilities that the system should possess. These include:

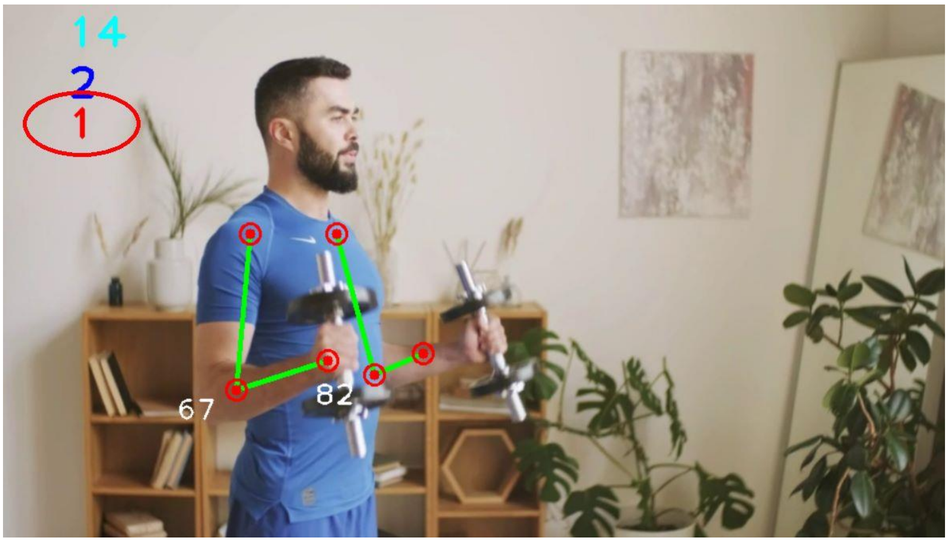
1. **Exercise Video Input:** The system should allow users to input exercise videos captured through a webcam or stored video files.

2. **Correctness Detection:** The system should compare the detected poses and movements against predefined correct exercise patterns to determine the correctness of each repetition or movement.
3. **Exercise Classification:** The system should classify different types of exercises, allowing it to provide specific feedback tailored to each exercise category.
4. **Performance:** The system should perform in real-time, with minimal latency between exercise detection and feedback display.

3.3.1 System Feature 1 – Correct Repetition Detection

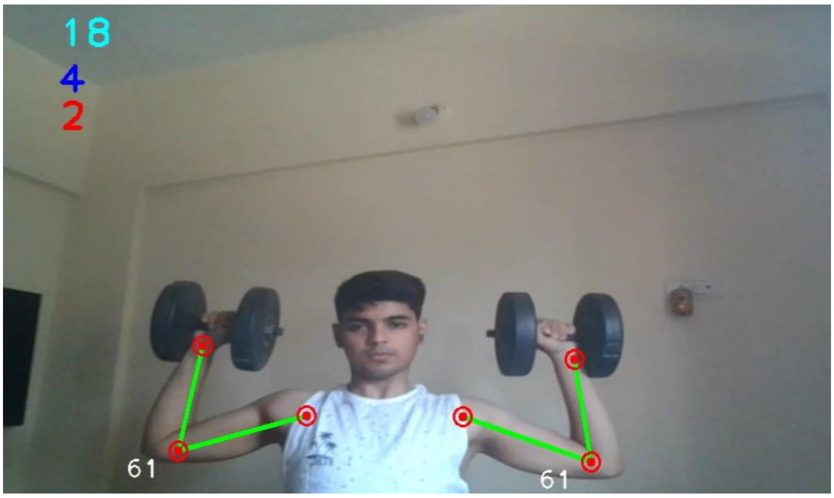


3.3.2 System Feature 2 – Incorrect Repetition Detection

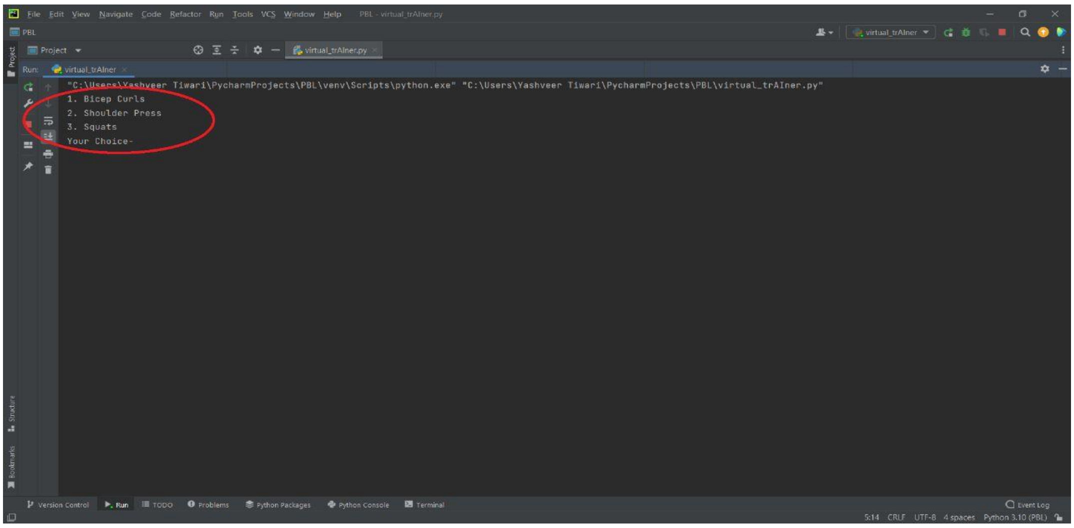


3.3.3 System Feature 3 – Video File Input

3.3.4 System Feature 4 – Webcam Input



3.3.5 System Feature 5 – Menu Driven UI to allow user to choose exercise



3.4 Non-Functional Requirements

The non-functional requirements of this project encompass various aspects beyond the core functionality. These requirements define the qualities and characteristics that the system should possess. Key non-functional requirements include:

1. **Accuracy:** The correctness detection algorithm should have a high level of accuracy in recognizing and classifying exercise poses and movements, minimizing false positives and false negatives.
2. **Usability:** The user interface should be intuitive, easy to navigate, and visually appealing, promoting user engagement and satisfaction.
3. **Compatibility:** The system should be compatible with various webcams and video file formats, allowing users to utilize different recording devices and input sources.

3.4.1 Performance Requirements

1. **Real-time Processing:** The system should process exercise videos and analyze pose data in real-time, providing immediate feedback to the user during their workout session.
2. **Low Latency:** The time between exercise detection and feedback display should be minimal, aiming for a latency of a few seconds or less to maintain a seamless user experience.
3. **Accuracy and Reliability:** The correctness detection algorithm should have a high level of accuracy, minimizing false positives and false negatives in identifying and classifying exercise poses and movements.

3.4.2 Safety/ Security Requirements

1. **Data Privacy:** The system should adhere to data privacy regulations and safeguard user data, ensuring that exercise videos and personal information are stored securely and accessible only to authorized individuals.
2. **Secure Data Transmission:** Any data transmitted between the user and the system, such as exercise videos or feedback, should be encrypted to protect against interception or tampering.
3. **Error Handling:** The system should have robust error handling mechanisms to handle unexpected situations gracefully, minimizing the risk of system vulnerabilities or crashes.

3.5 System Requirements

Hardware: The system should be compatible with standard desktop or laptop computers equipped with a webcam or compatible camera for video input.

Operating System: The system should be compatible with common operating systems such as Windows, macOS, and Linux, ensuring accessibility for a wide range of users.

Network Connectivity: The system may require internet connectivity for user authentication, software updates, and online support.

3.6 System Implementation Plan

Requirements Analysis: Review and analyze the project requirements, including functional and non-functional requirements, to gain a clear understanding of the system's scope and objectives.

Algorithm Development: Implement and refine computer vision algorithms for pose estimation and correctness detection, leveraging suitable libraries and frameworks.

Deployment: Prepare the system for deployment by configuring the necessary hardware and software infrastructure, including servers, databases, and web hosting environments.

User Testing and Feedback: Conduct user testing sessions to gather feedback and insights from users, making necessary refinements and improvements based on their input.

4. System Design

The system design of the exercise correctness detection project involves the arrangement and specification of the various components and modules that work together to achieve the desired functionality. The design focuses on capturing user exercise videos, analyzing poses, detecting correctness, and providing real-time feedback.

4.1 System Architecture Algorithms

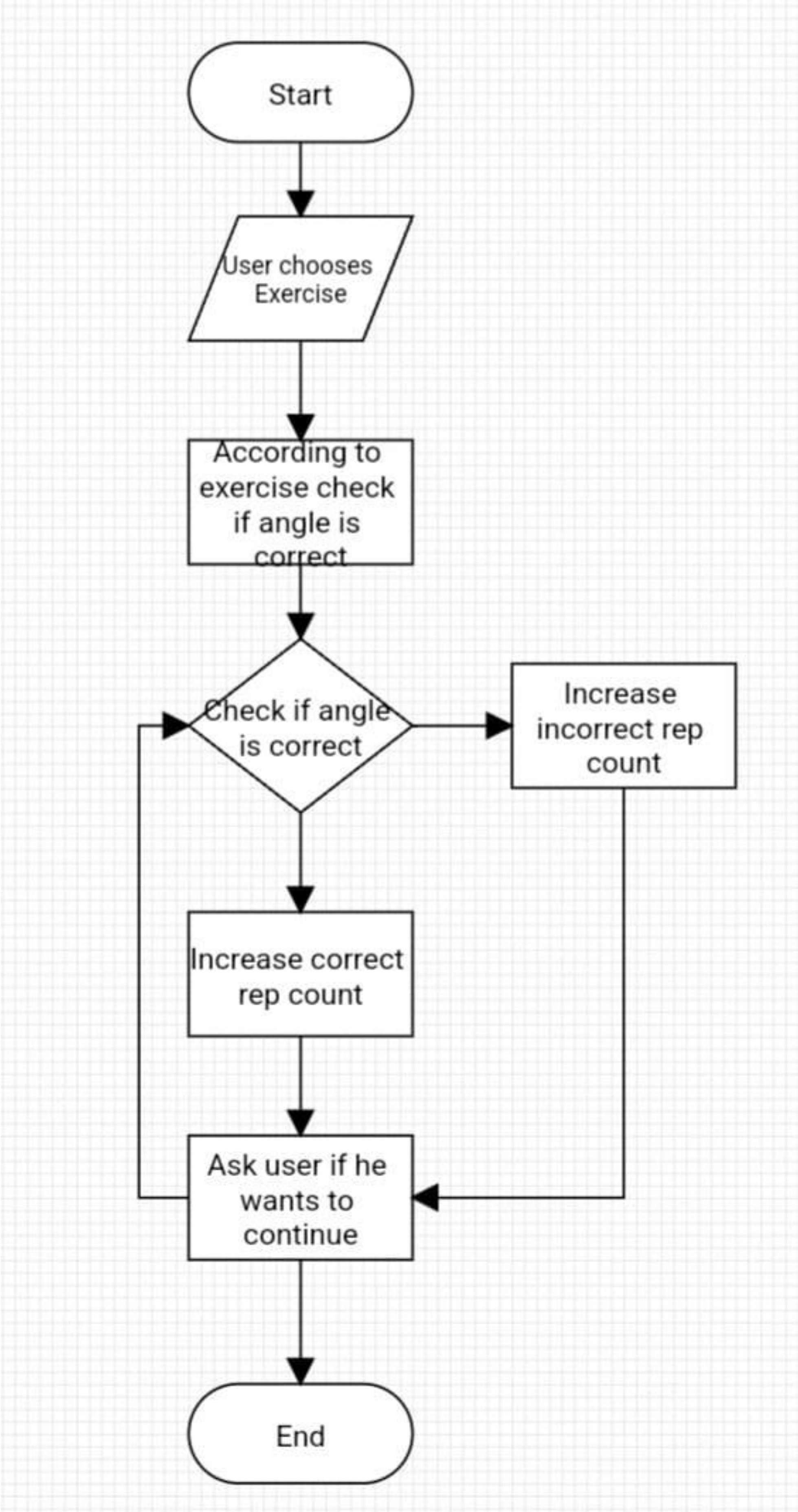
System Architecture:

The system architecture for the exercise correctness detection project involves the organization and structure of the system's components and their interactions. The key components include a user interface for user interaction, a video input module to handle exercise video input, a pose estimation module for analyzing poses, and a correctness detection module to assess exercise correctness. The architecture, thus, aims to provide a scalable, modular, and efficient solution for accurate exercise correctness detection.

Algorithms:

The exercise correctness detection project utilizes various computer vision algorithms to achieve its objectives. The algorithms leverage deep learning techniques and keypoint detection methods to track the user's body and identify specific joint positions. The correctness detection algorithm compares the detected poses against predefined correct exercise patterns, employing techniques like pattern matching or pose similarity measures. These algorithms work together to analyze exercise videos, assess correctness, and deliver timely and accurate feedback, enhancing the effectiveness of exercise performance.

4.2 Flowchart



4.3 Implementation/ Results

Implementation:

- The implementation of the exercise correctness detection system involves developing and integrating the various components and modules outlined in the system architecture. This includes implementing the user interface, video input module, pose estimation module, and the correctness detection module.
- The algorithms for pose estimation and correctness detection are implemented, utilizing appropriate computer vision libraries and frameworks.

Results:

- The exercise correctness detection system demonstrates its capability to accurately assess the correctness of exercise movements and provide real-time feedback to users.
- The system achieves a high level of accuracy in detecting and classifying exercise poses, minimizing false positives and false negatives.
- Users experience improved exercise performance through the system's feedback, resulting in better form, technique, and overall effectiveness of their workouts.
- User feedback and testing results show that the system is user-friendly and enhances the user's understanding and execution of correct exercise movements.

5. Other Specifications

5.1 Advantages

The system provides real-time correctness detection on exercises, allowing users to make immediate adjustments to their form and technique. This timely detection helps users maintain proper posture, reduce the risk of injury, and maximize the effectiveness of their workouts.

Additionally, the system's scalability enables it to accommodate many users simultaneously. This makes it suitable for various settings such as fitness centres, virtual training platforms, or home workouts where multiple users can benefit from real-time exercise correctness assessment.

Furthermore, the system promotes self-motivation and engagement by providing immediate and personalized feedback. Users receive encouragement and validation when their exercise movements align with correct form, fostering a sense of accomplishment and boosting their motivation to continue exercising.

5.2 Limitations

Limitations of the project include:

1. **Lack of UI:** other than console(only in the current version, the future versions will have appropriate UI)
2. **Accuracy Limitations**: The system's accuracy in detecting exercise correctness heavily relies on the quality of input videos and the effectiveness of the pose estimation algorithms.
3. **Limited Exercise Variety**: The system's correctness detection capabilities may be limited to specific exercise types or predefined patterns. It may not be able to evaluate the correctness of exercises that deviate significantly from the predefined patterns or involve complex movements.
4. **Dependency on Camera Quality**: The accuracy and performance of the system are influenced by the quality and resolution of the camera used for video input.
5. **User Adaptation**: The system may require users to adapt their exercise routines to fit the predefined patterns or pose estimation algorithms. This may limit the system's effectiveness for users with unique exercise styles or preferences.

5.3 Applications

The exercise correctness detection project has various potential applications in the field of fitness and exercise. Some of the key applications include:

Personal Training: The system can be utilized by personal trainers to provide real-time feedback and guidance to their clients during workout sessions. Trainers can remotely monitor their clients' exercise form and technique, ensuring proper execution and reducing the risk of injury.

Virtual Fitness Classes: The system can be integrated into virtual fitness platforms, allowing instructors to deliver interactive exercise classes to a large number of participants. Users can receive instant feedback and corrections, creating an engaging and immersive virtual fitness experience.

Home Workouts: The system is beneficial for individuals who prefer exercising at home without the guidance of a trainer. Users can follow exercise videos or programs and receive immediate feedback on their form, enabling them to perform exercises correctly and effectively.

Sports Training and Performance Enhancement: Athletes and sports professionals can benefit from the system's real-time feedback to refine their technique and optimize their performance. It can be used in various sports disciplines to improve movement precision, enhance skills, and prevent injuries.

6. Conclusion

In conclusion, this project successfully developed a CV system capable of detecting the correctness of exercises performed by individuals. By leveraging CV techniques and image processing algorithms, the system provided feedback on exercise performance, offering an objective assessment that reduces reliance on subjective observations. The CV system enables remote exercise monitoring, making it particularly valuable for online fitness programs or situations where individuals do not have access to on-site trainers. Trainers and instructors can remotely assess exercise correctness, provide personalized feedback, and guide individuals towards proper form, regardless of their physical location.

The exercise correctness detection project offers several possibilities for future scope and extensions. Some potential areas for further development and enhancement include:

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Expanding Exercise Library: The project can be extended by incorporating a broader range of exercises and movement patterns. This would allow users to receive feedback and guidance on a wider variety of exercises, catering to different fitness goals and preferences.

Social and Gamification Features: Adding social and gamification elements to the system can encourage user engagement and motivation. Features such as sharing achievements, competing with friends, or earning virtual rewards can create a supportive and interactive fitness community.

7. References

1. https://www.youtube.com/watch?v=01sAkU_NvOY&list=PLO3Mswsq1B25qhTTVOdpwiqTsG7BxeJ_J
2. https://www.youtube.com/watch?v=5kaX3ta398w&list=PLO3Mswsq1B25qhTTVOdpwiqTsG7BxeJ_J
3. https://www.computervision.zone/courses/advance-computer-vision-with-python/
4. https://www.freecodecamp.org
5. https://www.youtube.com/watch?v=01sAkU_NvOY&t=3109s
6. https://www.youtube.com/watch?v=5kaX3ta398w
7. https://www.youtube.com/watch?v=PkZNo7MFNFg&t=732s
8. https://www.youtube.com/watch?v=nu_pCVPKzTk&t=19054s