Leveraging Artificial Intelligence and Computer Vision for Effective Exercise Form Assessment

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Abstract—**FitVision uses AI and computer vision to transform fitness form assessment. Ensuring proper execution of exercises is crucial for preventing injuries and optimizing workouts. The device assesses body motions in real time and offers individualized feedback on alignment and range of motion. FitVision encourages safer and more efficient exercise by enabling individuals to enhance form on their own. FitVision is a trailblazing step toward a safer and more fulfilling fitness journey since it seamlessly incorporates technology into workout regimens.**

Keywords—AI, Computer Vision, real-time analysis, fitness industry

I. Introduction

In the tapestry of human well-being, health stands as a vital cornerstone, with regular physical exercise emerging as a pivotal thread. The well-established advantages of consistent exercise encompass improvements in cardiovascular vitality, enhanced muscular prowess, enduring stamina, meticulous weight management, and a significant reduction in susceptibility to chronic diseases such as heart disease, strokes, and diabetes. However, an often-underestimated aspect of these benefits is the profound influence of precise execution, where exercise form and technique hold a key position.

Recognizing the intricate interplay between fitness and form, our project, FitVision, seeks to address this critical aspect. FitVision embodies the development and implementation of advanced instruments tailored for the precise evaluation of exercise form, guided by the synergy of Artificial Intelligence (AI) and Computer Vision technologies.

II. Literature Review

We explored user experiences with AI fitness instructor apps, particularly the work of Garbett et al., which investigated aspects such as computer vision limitations and user adaptation. Their insights guided our design considerations for feedback systems and personalization, shaping our approach to user engagement[1].

In our exploration of pose estimation models, the work by Yu et al. introduced JCRA, a novel one-stage end-to-end algorithm for multi-person 2D pose estimation. This research emphasized the importance of speed, accuracy, and a symmetric network structure to enhance the identification of key points, influencing our decision-making in choosing an appropriate pose detection model for our system[2].

Additionally, studies such as those by Cao et al. and Bogo et al. contributed to our understanding of multi-person 2D pose estimation and 3D human pose and shape estimation from a single image. The methodologies presented in these works influenced our considerations in algorithm design, particularly in the context of joint detection, pose analysis, and constraints for accurate form assessment[3][4].

The literature survey also explored practical implementations, including the Pose Trainer system proposed by Chen and Yan, which used OpenPose for pose detection and machine learning models for posture evaluation[5]. The integration of OpenCV and MediaPipe for real-time pose detection in an AI personal trainer system, as described by Ohri et al., provided valuable insights into the practical application of these technologies[6]. These real-world implementations guided our approach to the development of a user-friendly graphical interface and the incorporation of pose detection into our system.

Furthermore, ethical considerations were drawn from studies like that of Papandreou et al., which highlighted privacy concerns associated with the collection of personal data and exercise videos. These insights influenced our approach to security algorithms, ensuring the protection of user data and privacy[7].

III. Traditional And Existing System

Traditionally, exercise form assessment relied on manual observation by fitness trainers, introducing subjectivity, high costs, and time constraints.[1] This approach lacked real-time feedback and often depended on trainer availability, limiting accessibility.

Current fitness apps and wearables offer form assessment features but may suffer from accuracy issues, limited exercise coverage, privacy concerns, and dependency on external devices. Some systems lack personalization, hindering their effectiveness.

IV. PROPOSED SYSTEM

FitVision application reimagines form scoring by combining AI with computer vision. With its innovative methodology focusing on usability, convenience, as well as live updates. An accompanying diagram shows the system's design that involves an automated process for precise pose detections.

The flexibility to work under low computations is at the very center of FitVision and should be considered as a major factor determining the choice of a framework. This ideology resonates with the application of the MediaPipe framework that requires low computing power to determine the joint coordinates of a user. The accuracy of pose detection determines the base on which the app operates.

As far as user journey in FitVision is concerned, it begins by choosing an exercise and hence the camera starts capturing motions. It is here that MediaPipe comes into focus, a well-known tool highly proficient in detecting joint coordinates, tracing and communicating the positions of respective joints. After that, OpenCV library performs an important function of calculating angles between joints and helping to reveal correct movement technique.

Differentiating FitVision from regular fitness apps is the immediate real-time feedback loop. For instance, adjustments happen in time, making work out safer and more effective for users. The media pipe has a very crucial role to play during this stage as it provides for up to 33 points accuracy and joint detection that perfectly matches fit vision needs of accurate estimations.

Such a flexible platform is necessary for FitVision as it facilitates different workouts. Here, MediaPipes versatility allows easy transitions when changing exercises, thus making the app effective.

Significantly, FtVision is oriented towards user accessibility. MediaPipe's integration as part of one of the subsystems or components in the application architecture provides support for real-time processing on low-powered devices as simple as Smartphones or embedded systems. The commitment to accessibility signifies a major step towards enhancing user accessibility to fitness assessment instruments.

FitVision prioritizes user experience and accessibility, integrating seamlessly with low-power devices via MediaPipe. This commitment extends beyond functionality to provide a user-friendly interface, democratizing fitness assessment. By bridging technology and accessibility, FitVision becomes a catalyst for healthier lifestyles, democratizing exercise analysis and optimization for all, regardless of technical resources. This synergy drives FitVision towards its goal of revolutionizing fitness assessment and fostering inclusivity in wellness.

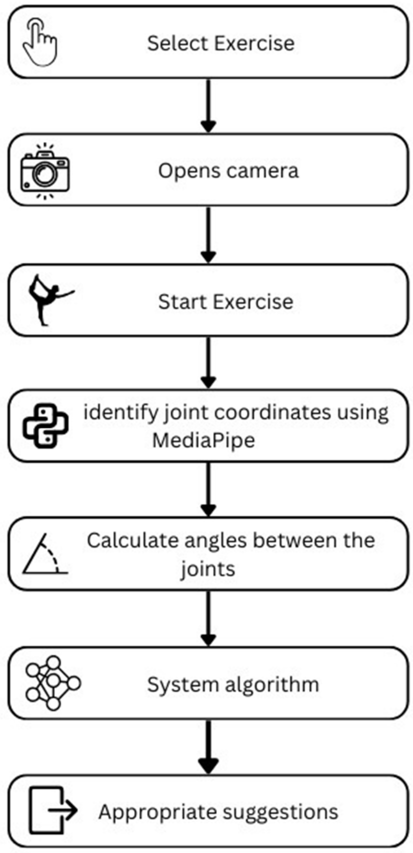

Fig 1: Process design and flow of FitVision application to achieve its functionality that includes user interactions, data processing, and the delivery of results.

TABLE I. COMPARATIVE ANALYSIS OF COMPUTER VISION FRAMEWORKS BASED ON KEY CRITERIA

Framework	OpenPose	MediaPipe	YOLOv7	DeepPose
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Model Complexity	Medium to High	Low To Medium	High	Medium to High
User - Friendliness	Moderate	High	Moderate	Moderate

V. ALGORITHM AND PROCESS DESIGN

A. Algorithm

1) *Pose Detection Algorithm:* Fitvision utilizes the MediaPipe framework for real-time pose detection. The algorithm continuously captures video frames from the user's camera and analyzes the frames to detect key body

landmarks, such as joints and body parts. This provides the foundational data for exercise analysis.

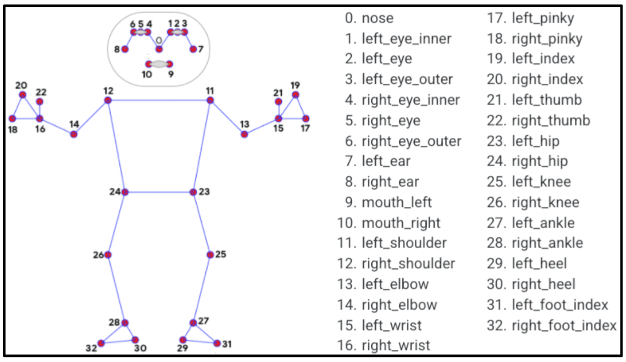

Fig 2:MediaPipe 33 landmarks on a human body model that enable pose estimation, tracking, and analysis.[8]

2) *Form Analysis :* Computer Vision techniques are applied to the detected poses. Fitvision's algorithm assesses the user's form and movement during exercises by comparing the user's actual pose to the expected ideal pose for a given exercise. Deviations from the correct form are identified.

B. *Process Design:*

The process encompasses video preprocessing, model development for exercise form. The following steps outline the comprehensive methodology for building the AI-driven exercise form assessment:

1) *GUI for Fitvision:*

- Fitvision's graphical user interface (GUI) facilitates user interaction while capturing and reviewing workouts.

- Users receive feedback in real-time while working out, and the UI makes this engagement possible.

2) *Video Preprocessing:*

- Video preprocessing tasks using OpenCV include normalizing pixel values, applying noise reduction techniques, and resizing video frames to a consistent resolution and frame rate.
- Standardize video inputs by resizing them to the same resolution and frame rate, ensuring consistency for subsequent analysis.
- Normalize pixel values in frames to enhance the performance of the pose estimation model.

3) *Pose Estimation Model:*

- Using Mediapipe to detect bodily joint positions.
- Integrate the chosen model into the project framework, including library installation, dependency setup, and interfaces for video input and joint position output.
- Utilize the pose estimation model to process all exercise videos, extracting joint locations such as elbow, knee, and shoulder coordinates.

4) *Feedback to User:*

- Summarize form feedback and offer suggestions for improvement to users based on the AI analysis.

5) *Testing and Validation:*

- Test the system using a diverse range of exercise videos to validate the accuracy of form assessment and the effectiveness of feedback provided.
- Fine-tune the model and algorithms based on testing outcomes, ensuring continuous improvement.

VI. OUTPUT

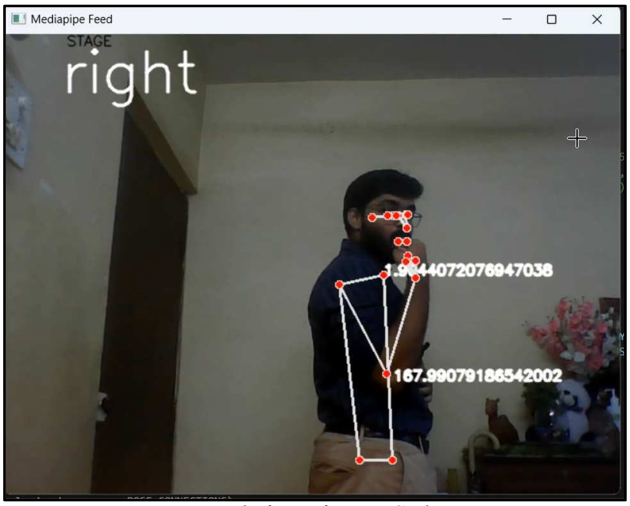

Fig 5: Right form of Bicep Curl exercise

After clicking the 'Start Exercise' button, a camera window will appear to analyze the exercise form using the algorithm, displaying the results accordingly.

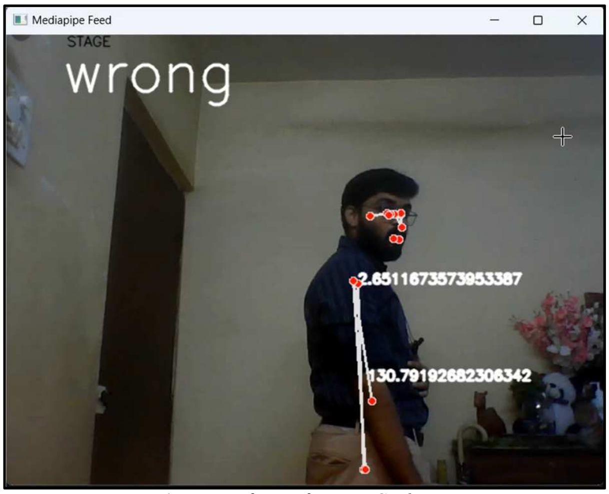

Fig 6: Wrong form of Bicep Curl exercise

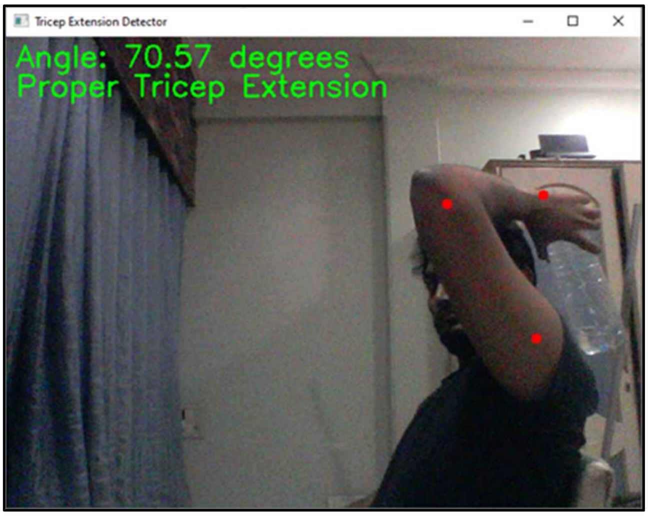

Fig 7: Calculating the angle between the points to assess the form of the one-arm tricep extension and ensure it falls within the proper threshold for an effective workout.

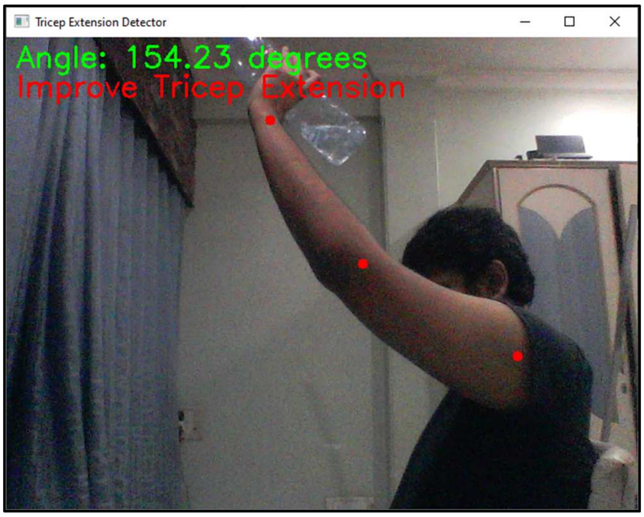

Fig 8: Checking for incorrect form by calculating the angle between the points during the one-arm tricep extension.

VII. Conclusion

One notable achievement towards incorporating technology in the fitness industry is the creation of FitVision. Due to the algorithm and innovative process design of the project, it has been possible to create a strong platform providing personalized feedback and real-time analysis to users, reshaping people's approach towards health exercises.

Algorithm design was stressed throughout the project. This was therefore ensured to make sure these models give precise pose detection, exercise analysis as well as customized feedback. For effective services delivery at FitVision, key characteristics like correctness, efficiency, clarity, and generally had been put into consideration to guarantee a good experience.

It is only through the amalgamation of technology and fitness that the project can succeed. FitVision's success stems from incorporating new methods such as advanced algorithms and process designs, which improve users' time in the gym. The project also places much emphasis on these qualities such as correctness, ease, clarity and generality, thereby maintaining quality of the system. Such a high attention towards quality is reflected in the proper pose detection and workout assessment delivered by the service. The combination of these features and the individualized response makes FitVision indispensable for those who want to boost their physique.

In addition, the possibilities offered by FitVision are enormous looking forward. The capabilities of the platform will grow along with the evolution of technology. By continuing to refine its algorithm design and process for the future, FitVision will continue leading the way in fitness innovation, providing users with the best possible instrument for their fitness pursuits. Even if you are an experienced athlete or beginning to exercise, FitVision will definitely make your journey towards health easier.

VIII. Future Work

As FitVision continues to evolve and grow, there are several avenues for future development and enhancement:

1) *Expanded Exercise Database:* Continuously update and expand the exercise database to cover a wider range of exercises, including specialized workouts for different fitness goals and preferences.

2) *Personalized Challenges and Achievements:* Integrate personalized fitness challenges and achievements to keep users motivated and engaged. Provide a gamified experience that encourages users to push their limits and celebrate their accomplishments.

3) *Physiotherapy Module:* Introduce a physiotherapy module to cater to users with specific rehabilitation needs. Incorporate guided exercises and routines recommended by physiotherapists for users recovering from injuries or seeking therapeutic workouts.

4) *Certified Trainer Partnership:* Forge partnerships with certified gym trainers and fitness experts to bring their expertise directly to Fitvision users. This collaboration will allow users to benefit from personalized training plans and advice tailored to their fitness goals.

5) *Feedback and Progress Reviews:* Implement a system where certified trainers can provide feedback and review user progress. This personalized interaction will offer users insights into their performance and areas for improvement, enhancing the effectiveness of their fitness journey.

6) *Security and Privacy Enhancements:* Stay updated with evolving data protection regulations and continuously improve security measures to safeguard user data and privacy.

7) *Android Application Development:* To broaden accessibility, FitVision will embark on the development of an Android application. This expansion to a mobile platform

will empower users to seamlessly integrate fitness into their lifestyles, bringing the transformative FitVision experience to a wider audience.

By focusing on these future work areas, FitVision aims to remain at the forefront of the fitness industry, leveraging advancements in computer vision to provide a comprehensive and inclusive platform for users worldwide. This journey to combine algorithm and process design with industry leading technologies will continue to shape the future of personalized fitness training and rehabilitation.

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by Kevin Patel

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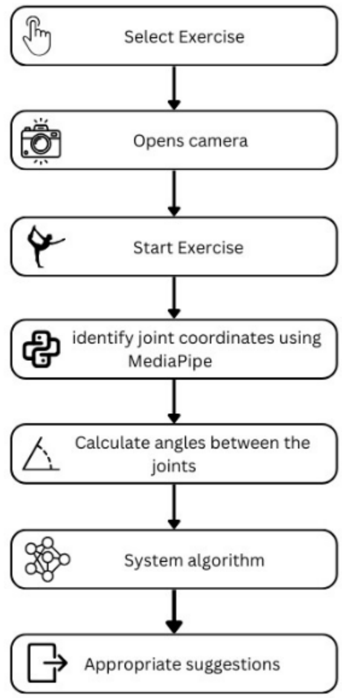

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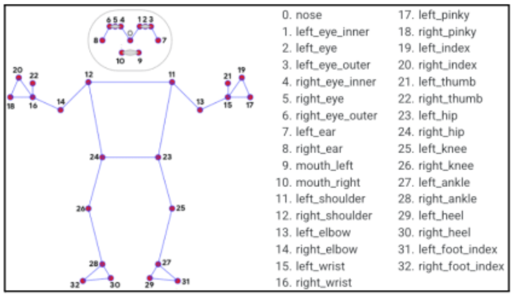
V. Algorithm And Process Design

A. Algorithm

1) Pose Detection Algorithm: Fitvision utilizes the MediaPipe framework for real-time pose detection. The algorithm continuously captures video frames from the user's camera and analyzes the frames to detect key body landmarks, such as joints and body parts. This provides the foundational data for exercise analysis.



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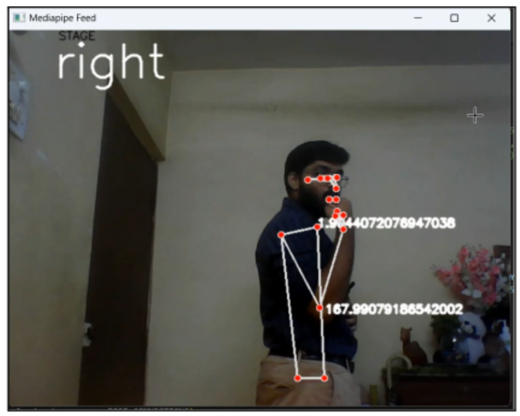
VI. Output



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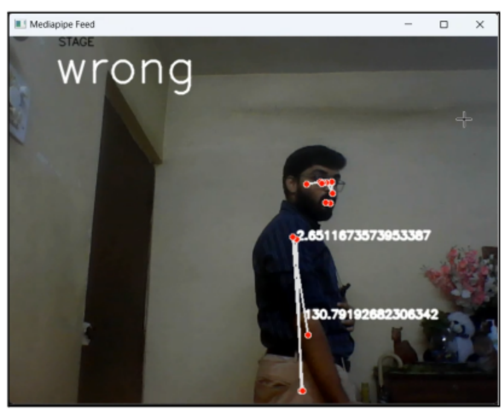

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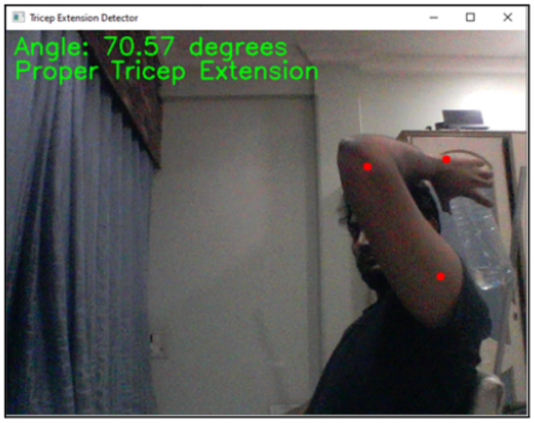

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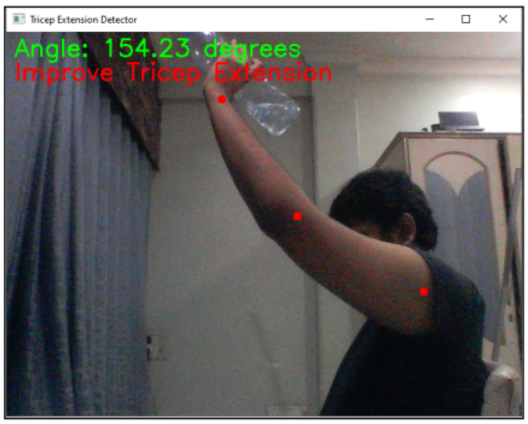

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One notable achievement towards incorporating technology in the fitness industry is the creation of FitVision. Due to the algorithm and innovative process design of the project, it has been possible to create a strong platform providing personalized feedback and real-time analysis to users, reshaping people's approach towards health exercises.

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It is only through the amalgamation of technology and fitness that the project can succeed. FitVision's success stems from incorporating new methods such as advanced algorithms and process designs, which improve users' time in the gym. The project also places much emphasis on these qualities such as correctness, ease, clarity and generality, thereby maintaining quality of the system. Such a high attention towards quality is reflected in the proper pose detection and workout assessment delivered by the service. The combination of these features and the individualized response makes FitVision indispensable for those who want to boost their physique.

In addition, the possibilities offered by FitVision are enormous looking forward. The capabilities of the platform will grow along with the evolution of technology. By continuing to refine its algorithm design and process for the future, FitVision will continue leading the way in fitness innovation, providing users with the best possible instrument for their fitness pursuits. Even if you are an experienced athlete or beginning to exercise, FitVision will definitely make your journey towards health easier.

VIII. Future Work

As FitVision continues to evolve and grow, there are several avenues for future development and enhancement:

1) *Expanded Exercise Database:* Continuously update and expand the exercise database to cover a wider range of exercises, including specialized workouts for different fitness goals and preferences.

2) *Personalized Challenges and Achievements:* Integrate personalized fitness challenges and achievements to keep users motivated and engaged. Provide a gamified experience that encourages users to push their limits and celebrate their accomplishments.

3) *Physiotherapy Module:* Introduce a physiotherapy module to cater to users with specific rehabilitation needs. Incorporate guided exercises and routines recommended by physiotherapists for users recovering from injuries or seeking therapeutic workouts.

4) *Certified Trainer Partnership:* Forge partnerships with certified gym trainers and fitness experts to bring their expertise directly to Fitvision users. This collaboration will allow users to benefit from personalized training plans and advice tailored to their fitness goals.

5) *Feedback and Progress Reviews:* Implement a system where certified trainers can provide feedback and review user progress. This personalized interaction will offer users insights into their performance and areas for improvement, enhancing the effectiveness of their fitness journey.

6) *Security and Privacy Enhancements:* Stay updated with evolving data protection regulations and continuously improve security measures to safeguard user data and privacy.

7) *Android Application Development:* To broaden accessibility, FitVision will embark on the development of

an Android application. This expansion to a mobile platform will empower users to seamlessly integrate fitness into their lifestyles, bringing the transformative FitVision experience to a wider audience.

By focusing on these future work areas, FitVision aims to remain at the forefront of the fitness industry, leveraging advancements in computer vision to provide a comprehensive and inclusive platform for users worldwide. This journey to combine algorithm and process design with industry leading technologies will continue to shape the future of personalized fitness training and rehabilitation.

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