VIVEKANAND EDUCATION SOCIETY'S INSTITUTE OF TECHNOLOGY

(An Autonomous Institute Affiliated to University of Mumbai)

Department of Computer Engineering

V.E.S.

Since 1962

Project Report on

FitVision: Smart Posture Analysis for Effective Workouts

Submitted in partial fulfillment of the requirements of the degree

BACHELOR OF ENGINEERING IN COMPUTER ENGINEERING

By

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(AY 2023-24)

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CERTIFICATE

This is to certify that the Mini Project entitled **"FitVision: Smart Posture Analysis for Effective Workouts"** is a bonafide work of **Dhruva Chaudhari (03), Kevin Patel(45), M.Kaif Qureshi (48), Krishnam Raja (49)** submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of **"Bachelor of Engineering"** in **"Computer Engineering" .**

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Mini Project Approval

This Mini Project entitled "**FitVision: Smart Posture Analysis for Effective Workouts"** by **Dhruva Chaudhari (03), Kevin Patel(45), M.Kaif Qureshi (48), Krishnam Raja (49)** is approved for the degree of **Bachelor of Engineering** in **Computer Engineering.**

Examiners

1……………………………………………

(Internal Examiner Name & Sign)

2……………………………………………

(External Examiner name & Sign)

Date:

Place:

Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Index

List of Figures

List of Tables

Abstract

The “FitVision: A Solution for Accurate Exercise Form Assessment” project aims to develop an innovative system that leverages the power of Artificial Intelligence (AI) and Computer Vision to enhance exercise form assessment. With a growing focus on health and fitness, proper exercise form is crucial to avoid injuries and optimize workout effectiveness. FitVision addresses this challenge by utilizing advanced computer vision techniques to detect and analyze a person's exercise form.

KEYWORDS- AI, Computer Vision, Fitness

Chapter 1: Introduction

1.1 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.

1.2 Motivation

The journey towards personal health and well-being is a path we all tread throughout our lives. At its core, this journey is not merely a pursuit of aesthetics or physical prowess; it is a quest for vitality, resilience, and a higher quality of life. Each day presents an opportunity to take a step towards a healthier, happier self, and it is with this profound belief that we embark on our mission.

Our motivation is rooted in a deep understanding of the vital role that health and well-being play in our lives. A sound body and mind are not only assets but also prerequisites for realizing our dreams, cherishing our relationships, and experiencing the beauty of life to the fullest. We recognize that personal health and well-being are the cornerstones upon which every other aspect of our existence rests.

Moreover, our project, "FitVision: Smart Posture Analysis for Effective Workouts," resonates with the conviction that we can utilize the power of technology to enhance our health journeys. By leveraging artificial intelligence and computer vision, we seek to not only exercise smarter but also more safely. We aspire to empower individuals with the knowledge and tools to exercise with precision, to reduce the risk of injuries, and to revel in the joy of progress.

1.3 Problem Definition

In the pursuit of a healthy lifestyle and fitness goals, individuals often engage in various exercise routines. However, ensuring proper exercise form is essential to prevent injuries and maximize workout effectiveness. Traditional methods of assessing exercise form rely on manual observation, which can be subjective and error-prone. To address this challenge, our project, FitVision, seeks to leverage cutting-edge technologies - Artificial Intelligence (AI) and Computer Vision - to provide a comprehensive and accurate solution for exercise form assessment.

1.4 Existing Systems

1. **Manual Observation and Correction:**
   - This traditional method relies on fitness trainers or coaches to visually assess individuals' exercise form and provide feedback or corrections.
   - While it allows for real-time feedback and correction, it can be subjective and may vary depending on the expertise of the trainer.
   - Additionally, it may not be scalable for large groups or individuals without access to personal trainers.
2. **Wearable Devices:**
   - Wearable devices like fitness trackers or smartwatches often include accelerometers, gyroscopes, and other sensors to track movements during exercises.
   - These devices can provide quantitative data on metrics like movement range, repetitions, and intensity.
   - However, they may not offer detailed feedback on form and technique, focusing more on activity tracking and overall performance.
3. **Video Analysis Software:**
   - Video analysis software allows users to record their workouts and then analyze them later to assess form and technique.
   - Users can review their movements frame by frame, enabling a more detailed evaluation.
   - However, this method can be time-consuming and may require expertise to accurately interpret the data.

1.5 Lacuna of the existing systems

1. Accuracy and Reliability of AI Components: The AI model demonstrated inconsistent performance, with inaccuracies in joint detection and occasional false positives and negatives, impacting its overall reliability in providing accurate exercise form assessments. Variability in lighting conditions further exacerbated the accuracy issues, making it challenging to maintain dependable results in different environments.

2. Ethical, Social, and Privacy Implications: Privacy concerns arose due to the system's collection of personal data and exercise videos, necessitating the implementation of robust data protection measures to address these ethical and privacy-related lacunas. Users expressed concerns regarding the system's potential to amplify body image issues and set unrealistic expectations, emphasizing the need to consider the ethical and social implications of its use.

3. Diversity and Accessibility: The AI model struggled to recognize exercises performed by individuals from diverse backgrounds, leading to issues related to representation and inclusivity in the system. Accessibility concerns surfaced as the user interface design failed to accommodate the needs of users with disabilities, impacting the overall usability and inclusivity of the system.

4. Occlusion and Crowded Scenes: In traditional methods of assessing exercise, issues emerged with occlusion, where exercise movements were obscured by objects or other individuals in crowded gym or fitness class settings, affecting the accuracy of form assessment. Crowded fitness classes posed a challenge for trainers attempting to monitor each participant's form, making it difficult to provide precise feedback, highlighting the limitations of manual observation in such scenarios.

1.6 Relevance of the Project

1. **Health and Fitness Enhancement:** FitVision directly contributes to enhancing the health and fitness journey of individuals by focusing on the crucial aspect of exercise form. By providing accurate assessments of exercise form, it helps users optimize their workouts, reduce the risk of injuries, and improve overall effectiveness, thus promoting long-term health benefits.
2. **Technological Advancement:** The project leverages cutting-edge technologies like Artificial Intelligence and Computer Vision to create an innovative solution. By harnessing the power of these technologies, FitVision represents a significant

advancement in the realm of fitness technology, demonstrating the potential of AI and computer vision in improving personal health outcomes.

3. **Accuracy and Reliability:** FitVision aims to address the limitations of existing systems by enhancing the accuracy and reliability of exercise form assessment. Through its utilization of AI and computer vision, it offers a more objective and consistent evaluation compared to traditional manual observation methods, thereby increasing confidence in the assessment results.
4. **Ethical and Social Responsibility:** The project acknowledges and addresses ethical, social, and privacy implications associated with its implementation. By prioritizing data protection measures and considering potential impacts on body image and inclusivity, FitVision demonstrates a commitment to responsible technology development and user well-being.
5. **Accessibility and Inclusivity:** FitVision endeavors to improve accessibility and inclusivity in fitness technology by recognizing and addressing challenges related to diversity and representation. By ensuring that its AI model can accurately recognize exercises performed by individuals from diverse backgrounds and accommodating the needs of users with disabilities, FitVision aims to create a more inclusive fitness environment.
6. **Practical Application:** FitVision's focus on real-world scenarios, such as occlusion and crowded scenes in gym settings, highlights its practical relevance and applicability. By tackling these challenges, the project aims to provide practical solutions that can be seamlessly integrated into everyday fitness routines, benefiting both users and fitness professionals.

Chapter 2: Literature Survey

2.1 Research Papers Referred

a. Inference drawn

Sr No.	Title	Inference
1	Towards Accurate Multi- person Pose Estimation in the Wild	The method uses a two-stage process for multi-person pose estimation: Faster RCNN identifies people in bounding boxes, then a ResNet estimates key points within these boxes, generating precise predictions using a unique aggregation method.
2	Real-time human pose recognition in parts from single depth images	Feature extraction: Identifying relevant features from image or video data, including edges, shapes, and textures. Classification: Categorizing these features into body parts using machine learning methods like SVMs or neural networks.
3	Towards Understanding People's Experiences of AI Computer Vision Fitness Instructor Apps	The study, involving 12 participants, evaluated five AI fitness instructor apps, identifying themes like computer vision limitations and user engagement. Insights from participant interviews led to design considerations in feedback, personalization, and AI interaction.
4	Joint Coordinate Regression and Association For Multi-Person Pose Estimation, A Pure Neural Network Approach.	The project introduces JCRA, a one-stage end-to-end multi-person 2D pose estimation algorithm. It produces human pose joints and associations without post-processing. JCRA is fast, accurate, and features a symmetric network structure for high accuracy in key point identification.
5	Realtime Multi-Person 2D Pose	The image is processed through a baseline

	Estimation using Part Affinity Fields	network (first 10 layers of VGG-19) to extract feature maps, then a multi-stage CNN generates Part Confidence Maps and Part Affinity Fields. Finally, a greedy algorithm determines the poses of individuals in the image using these maps and fields.
6	Keep it SMPL: Automatic Estimation of 3D Human Pose and Shape from a Single Image	The process includes detecting 2D joint locations with a CNN-based method such as DeepCut, fitting a 3D SMPL model to these locations by minimizing an objective function, and enforcing constraints on pose and shape to prevent interpenetration of the 3D model.
7	Pose Trainer: Correcting Exercise Posture using Pose Estimation	The paper details Pose Trainer's technical approach, a multi-stage pipeline. It begins with video recording, followed by pose estimation using deep convolutional neural networks, leveraging OpenPose for detecting human body keypoints. Posture evaluation follows, utilizing heuristic-based and machine learning models to assess pose quality.
8	AI Personal Trainer Using Open CV and Media Pipe	OpenCV marks an exoskeleton on the user's body and displays reps count on the screen. Media Pipe utilizes Blaze Pose to detect the user's body form during the workout. Flask develops the web application's front-end. ChatterBot implements the chatbot for user queries. Numpy extracts data points, and the COCO Dataset addresses scale variance in body sections.

Table 1 : Inference drawn from literature review

Chapter 3: Requirement Gathering for the Proposed System

3.1 Introduction to requirement gathering

Requirement gathering involves identifying, documenting, and analyzing the needs and expectations of stakeholders to define the functionalities and features that the system must possess. This section provides an overview of the requirement gathering process for FitVision, outlining the key objectives, stakeholders involved, and methods employed to gather requirements effectively.

Objectives of Requirement Gathering:

- **Understanding User Needs:** The primary objective of requirement gathering is to gain a comprehensive understanding of the needs, preferences, and expectations of FitVision's target users. This involves identifying the specific challenges users face in assessing exercise form and determining their preferences for features and functionalities.
- **Defining System Scope**: Requirement gathering helps in defining the scope of the FitVision system by outlining the features, functionalities, and constraints that need to be considered during the development process. This ensures that the final product aligns with the expectations and objectives of stakeholders.
- **Prioritizing Requirements:** By gathering requirements from various stakeholders, it becomes possible to prioritize them based on their importance and feasibility. This helps in allocating resources efficiently and focusing on the most critical aspects of the system.
- **Ensuring Stakeholder Alignment:** Requirement gathering facilitates communication and collaboration among stakeholders, including developers, users, and other relevant parties. It ensures that all stakeholders are aligned in terms of the system's goals, objectives, and functionalities.

Stakeholders Involved:

- **End Users:** The primary stakeholders of FitVision are the individuals who will use the system to assess their exercise form and receive feedback. Their input is crucial for understanding user needs and preferences.
- **Fitness Trainers/Coaches:** Fitness trainers and coaches are another key stakeholder group as they provide valuable insights into the requirements for assessing exercise form accurately and providing relevant feedback.

- **Healthcare Professionals:** Healthcare professionals, such as physical therapists or sports medicine specialists, may also provide input into the requirement gathering process, particularly regarding the prevention of injuries and the promotion of safe exercise practices.
- **Technical Team:** The technical team responsible for developing FitVision, including software engineers, and UI/UX designers, are essential stakeholders involved in requirement gathering. Their expertise is needed to translate user needs into technical specifications and design considerations.

3.2 Functional Requirements

Functional requirements specify the essential functionalities and features that the FitVision system must possess to meet the needs of its users. These requirements define what the system should do in terms of its operations and capabilities. The table below outlines the functional requirements for FitVision:

Requirement ID	Requirement Description
FR-01	**User Registration:** Allow users to create accounts and provide basic information for personalized experiences.
FR-02	**Exercise Recording:** Enable users to record videos of themselves performing exercises using their device camera.
FR-03	**Pose Detection:** Utilize computer vision algorithms to detect and track key body landmarks in recorded videos.
FR-04	**Form Analysis:** Analyze users' exercise form based on detected poses and compare it with ideal form guidelines.
FR-05	**Real-time Feedback:** Provide users with real-time feedback on their exercise form and suggestions for improvement.
FR-06	**Workout Progress Tracking:** Track users' workout history, including exercise duration, repetitions, and feedback.
FR-07	**Personalized Workouts:** Generate personalized workout plans based on users' fitness goals and preferences.

FR-08	**Security Measures:** Implement measures to ensure the security and privacy of user data and interactions.

Table 2 : Functional Requirement of the system

3.3 Non-Functional Requirements

Non-functional requirements specify the quality attributes and constraints that the FitVision system must adhere to in terms of performance, usability, security, and other aspects. These requirements define how well the system should perform rather than what it should do. The table below outlines the non-functional requirements for FitVision:

Requirement ID	Requirement Description
NFR-01	**Performance:** Ensure that the system responds promptly to user interactions and can handle multiple concurrent users.
NFR-02	**Usability:** Design the user interface to be intuitive, user-friendly, and accessible to users of all skill levels.
NFR-03	**Security:** Implement robust security measures, including data encryption, user authentication, and secure data storage.
NFR-04	**Reliability:** Ensure that the system operates reliably without frequent disruptions or downtime.
NFR-05	**Scalability:** Design the system to scale effectively to accommodate a growing user base and increasing workload.
NFR-06	**Compatibility:** Ensure compatibility with a wide range of devices, browsers, and operating systems.
NFR-07	**Privacy:** Protect user privacy by adhering to data protection regulations and minimizing the collection of personal information.

Table 3: Non-Functional Requirement of the system

3.4.Hardware, Software , Technology and tools utilized

The FitVision system utilizes a combination of hardware, software, technologies, and tools to implement its functionalities effectively.

Hardware

- **Webcam or External Camera:** Used for recording workout videos and capturing user movements.
- **Sufficient RAM [>=4GB]:** Required for memory-intensive computations during video preprocessing and model training.

Software

- **Programming Languages:** [Python] Used for implementing core system functionalities and algorithms.
- **Web Browsers;** [Google Chrome, Mozilla Firefox, etc.] Web browsers enable users to access the FitVision web application for viewing workout plans, feedback, and progress.
- **Computer Vision Libraries:** [OpenCV] Utilized for image and video processing tasks, including pose detection and tracking.
- **Web Development Frameworks:** [Flask] Used for developing the backend server and API endpoints for the FitVision web application.
- [React] We have created user interface using this framework

Technology

- **Artificial Intelligence (AI)**: Leveraged for advanced pose detection, form analysis, and personalized feedback generation.
- **Computer Vision :** Employed for analyzing users' exercise form and providing real-time feedback based on detected poses.

Tools

- **MediaPipe :** Utilized for real-time pose detection and tracking, enabling accurate analysis of users' exercise movements.
- **Integrated Development Environments (IDEs):** Used for writing, testing, and debugging code, such as PyCharm, Visual Studio Code.
- **Version Control Systems** (e.g., Git): Employed for collaborative development and version management of the FitVision codebase.

3.5 Constraints

Constraints represent the limitations or restrictions that impact the design, development, and implementation of the FitVision system. These constraints may arise due to technical, regulatory, or organizational factors. The table below outlines the constraints for FitVision:

Constraint ID	Constraint Description
C-01	**Hardware Limitations:** The system's performance may be constrained by the hardware capabilities of users' devices, such as processing power and memory.
C-02	**Data Privacy Regulations:** FitVision must comply with data protection regulations, limiting the collection, storage, and usage of personal information.
C-03	**Time Constraints:** There may be deadlines or time constraints for the development and release of FitVision, requiring efficient project management and prioritization of tasks.
C-05	**Integration Challenges**: Integration with external systems or APIs may present technical challenges, such as compatibility issues and data format discrepancies.

Table 4: Constraint of the system

Chapter 4: Proposed Design

4.1 Block diagram of the system

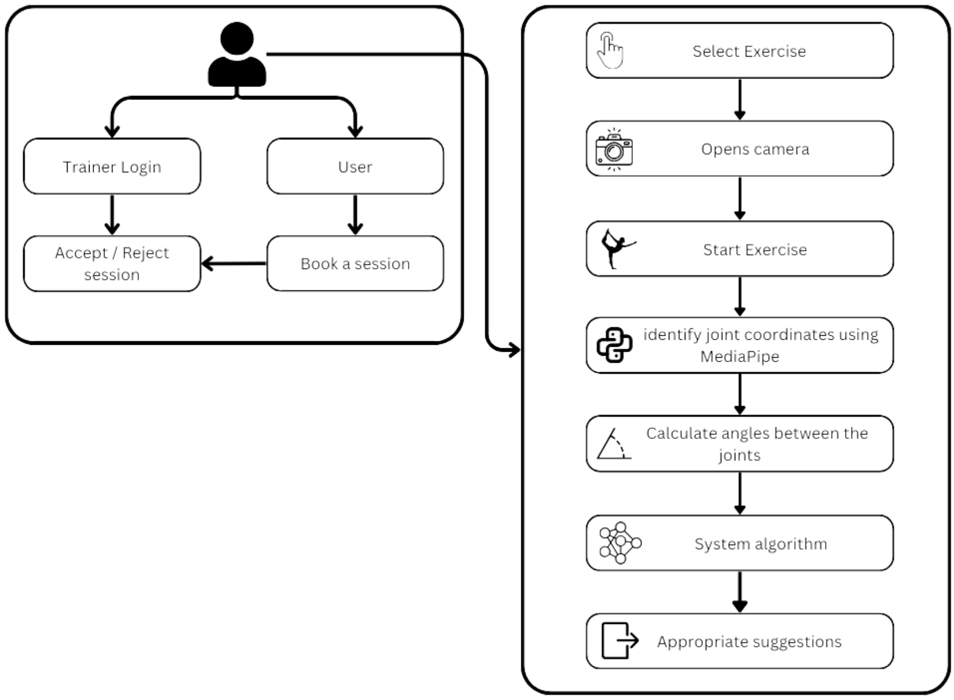

Fig 4.1.1 : Block diagram

- **Select Exercise:** This block represents the user interface (UI) element where users can select a specific exercise they want to perform. The application may provide a library of exercises or allow users to create custom workouts.
- **User Login:** This block is for the user to login to the system for either booking a session with the trainer or use the system for form assessment.
- **Trainer Login:** This block is for a personal trainer to log in to the system. It would include accepting or rejecting a session that the user has booked.
- **Opens Camera:** This block initiates the use of the laptop's camera to capture video of the user performing the exercise.
- **Identify joint coordinates using MediaPipe:** This block refers to using MediaPipe, an open-source framework that can process video and track body keypoints (joints). This would be used to identify a user's joints (e.g., elbows, knees, wrists) in each frame of the video.
- **Calculate angles between joints:** This block calculates the angles between different joints of the user's body. This information is essential to assess the user's form and posture during the exercise.

- **System Algorithm:** This block represents the core logic of the application that analyzes the calculated joint angles. The system algorithm would determine how well the user's form matches the ideal form.
- **Accept/Reject session:** This block is for a professional to accept or reject a session booked by the user
- **Book a session:** This block allows users to book a session with a personal trainer.
- **Appropriate suggestions:** This block refers to feedback that the application provides to the user on their form.

4.2 Project Scheduling Gantt Chart

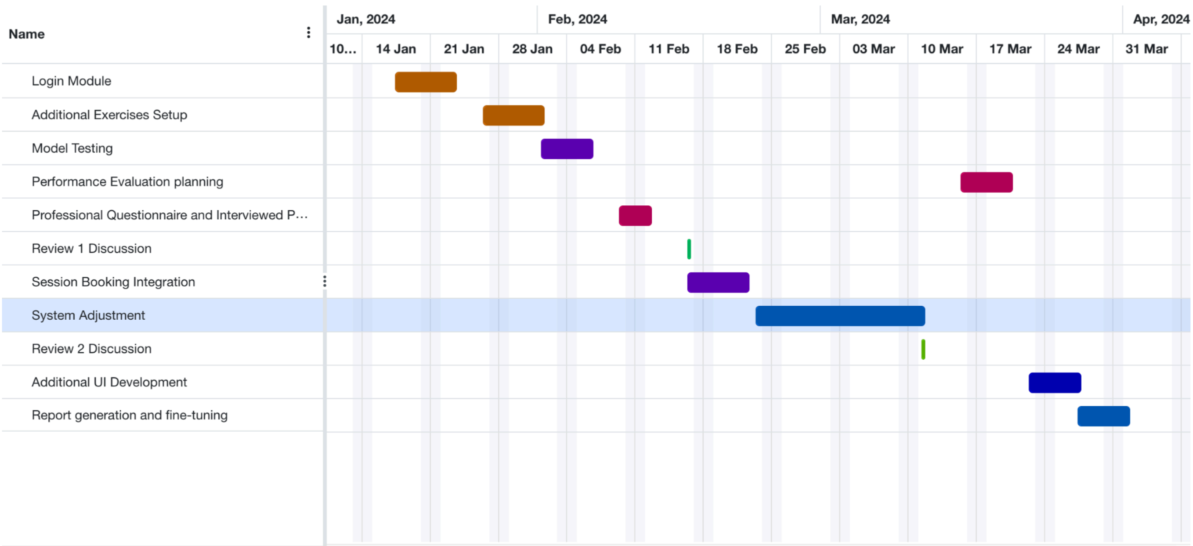

Figure 4.2.1 Gantt chart

Chapter 5: Implementation of the Proposed System

5.1. Methodology employed for development

The development of the FitVision system follows a systematic methodology that encompasses various stages, from initial planning to implementation and testing. The methodology ensures the efficient and structured development of the system, facilitating the achievement of project objectives. Below is an overview of the methodology employed for the development of FitVision:

1) Requirement Analysis:

- The first phase involves a thorough analysis of requirements gathered from stakeholders, including users, fitness experts, and developers.
- Functional and non-functional requirements are identified and documented to serve as a blueprint for system development.

2) Design Phase:

- In this phase, the system architecture and design are formulated based on the gathered requirements.
- Design decisions include selecting appropriate technologies, defining data models, and outlining system components and interactions.

3) Implementation:

- Development begins according to the design specifications laid out in the previous phase.
- Software modules are coded using programming languages and frameworks chosen during the design phase.
- Algorithms for pose detection, form analysis, and feedback generation are implemented to provide core functionalities of the system.

4) Testing:

- Each module and component undergoes rigorous testing to ensure its functionality and reliability.
- Unit tests, integration tests, and system tests are conducted to identify and resolve any issues or bugs.

5) Deployment:

- Once testing is completed, the system is deployed to a production environment.
- Deployment involves configuring servers, setting up databases, and ensuring scalability and reliability.

6) User Training and Acceptance:

- Users are provided with training and guidance on how to use the FitVision system effectively.
- Feedback from users is collected and incorporated to improve system usability and user experience.

7) Maintenance and Updates:

- Continuous maintenance and updates are performed to address bugs, add new features, and enhance system performance.
- Regular monitoring and optimization ensure the long-term reliability and functionality of the FitVision system.

5.2 Algorithms and flowcharts for the respective modules developed

Pose Detection Algorithm:

The pose detection algorithm employed in FitVision utilizes the MediaPipe framework for real-time detection of key body landmarks.

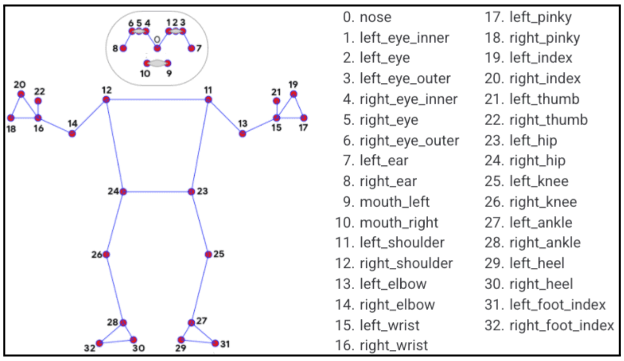

Fig 5.2.1 : MediaPipe 33 landmarks on a human body model that enable pose estimation, tracking, and analysis.

Flowchart:

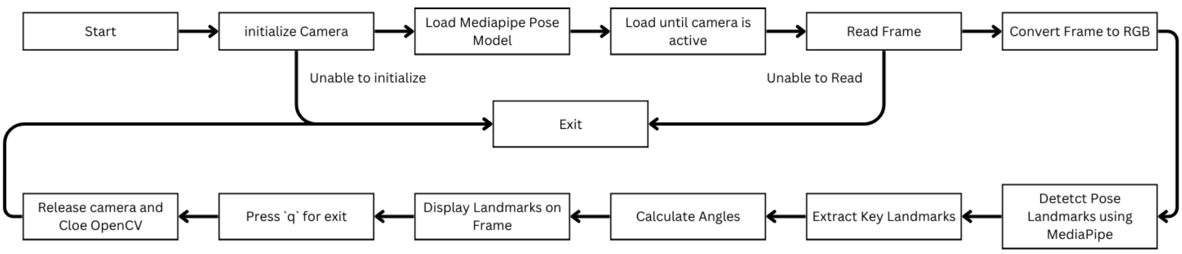

Fig 5.2.2 : Flowchart of Pose Detection algorithm

Form Analysis Algorithm:

The form analysis algorithm assesses the user's exercise form by comparing detected poses with ideal form templates.

Flowchart:

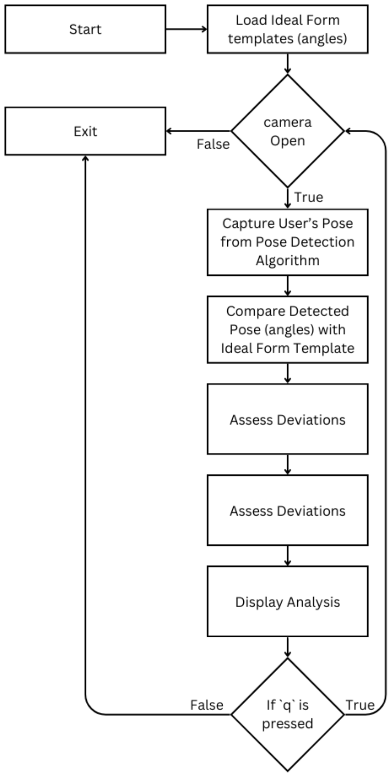

Fig 5.2.3 : Flowchart of Form Analysis algorithm

Feedback Generation Algorithm:

Based on the analysis of form deviations, the feedback generation algorithm generates real-time feedback and recommendations for users.

Flowchart:

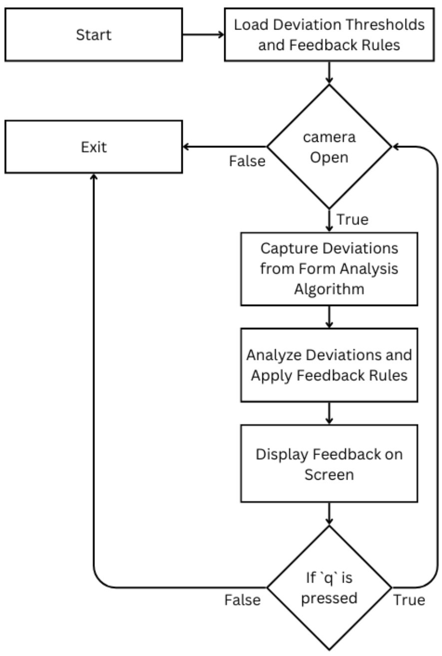

Fig 5.2.4 : Flowchart of Feedback Generation algorithm

Chapter 6: Testing of the Proposed System

6.1. Introduction to testing

Testing is the process of assessing a system or application to make sure it performs as planned and complies with requirements. It plays a vital role in software development by assisting in the early detection of flaws, mistakes, and vulnerabilities. Testing guarantees that the program operates as intended under a variety of circumstances and is dependable and functional.

Importance of testing:

Testing is essential to software development for a number of reasons.

1. Finding Defects: Testing assists in finding bugs, mistakes, and other software flaws so that developers can address them before release.
2. Testing makes sure the program satisfies quality requirements and functions dependably in many settings and scenarios.
3. Verifying Requirements: Testing ensures that the program satisfies the requirements and operates in accordance with stakeholder expectations.
4. Avoiding Expensive Mistakes: It is less expensive to find and correct faults early in the development process than to deal with them after deployment.

Types of testing:

Testing has several forms and is done at different stages of the software development lifecycle. The following are a few typical test kinds:

1. Unit testing verifies that separate code segments or components operate as intended when left alone.
2. Integration testing examines how various modules or units interact with one another to make sure everything functions as it should.
3. System testing verifies the functionality and behavior of the complete system against predetermined requirements by testing it as a whole.
4. Performance testing measures the software's responsiveness, scalability, and performance under various load scenarios.
5. Testing software's security features to find flaws and guarantee data protection is known as security testing.

6.2 Various test case scenarios considered

Test Case ID	Test Case Description	Test Steps	Test Data	Expected Results	Pass/Fail
TC-01	User Registration	1. Navigate to the registration page. 2. Fill in all required fields with valid information. 3. Click on the "Register" button.	User details (name, email, password, etc.)	User account is successfully created.	Pass
TC-02	Pose Detection	1. Go to the explore page and select the exercise. 2. Wait for 30 sec to start the camera and pose detection process to complete.	Live VideoFeed	Key body landmarks are accurately detected and tracked.	Pass
TC-03	Real-time Feedback	1. Perform an exercise in front of the camera. 2. Observe real-time feedback provided by FitVision.	Live video feed	FitVision provides real-time feedback on exercise form.	Pass
TC-04	Performance	1. Simulate multiple user interactions simultaneously. 2. Measure system response time.	Concurrent user interactions	FitVision responds promptly to user interactions under load.	Pass
TC-05	Usability	1. Ask users of varying skill levels to navigate the app. 2. Collect feedback on ease of use.	Users with different skill levels	FitVision interface is intuitive and user-friendly.	Pass
TC-06	Compatibility	1. Access FitVision from different devices, browsers, and operating systems.	Various devices, browsers, OS	FitVision is compatible and functions correctly across platforms.	Pass
TC-07	Privacy	1. Review data protection measures implemented by FitVision.	Privacy policy, data protection measures	User data is securely stored and protected according to regulations.	Pass
TC-08	Session Booking	1. Select the trainer from trainer page 2. Select the date and time with trainer 3. After confirmation both parties will receive confirmation mail with meet link	Trainer detail and available timings	Confirmation mail and google meet link generated for session	Pass

Table 5: Test cases

Chapter 7: Results and Discussion

7.1. Screenshots of User Interface (UI) for the respective module

The User Interface consist of

- **Home page:** The Home Page serves as the main entry point for users visiting your website

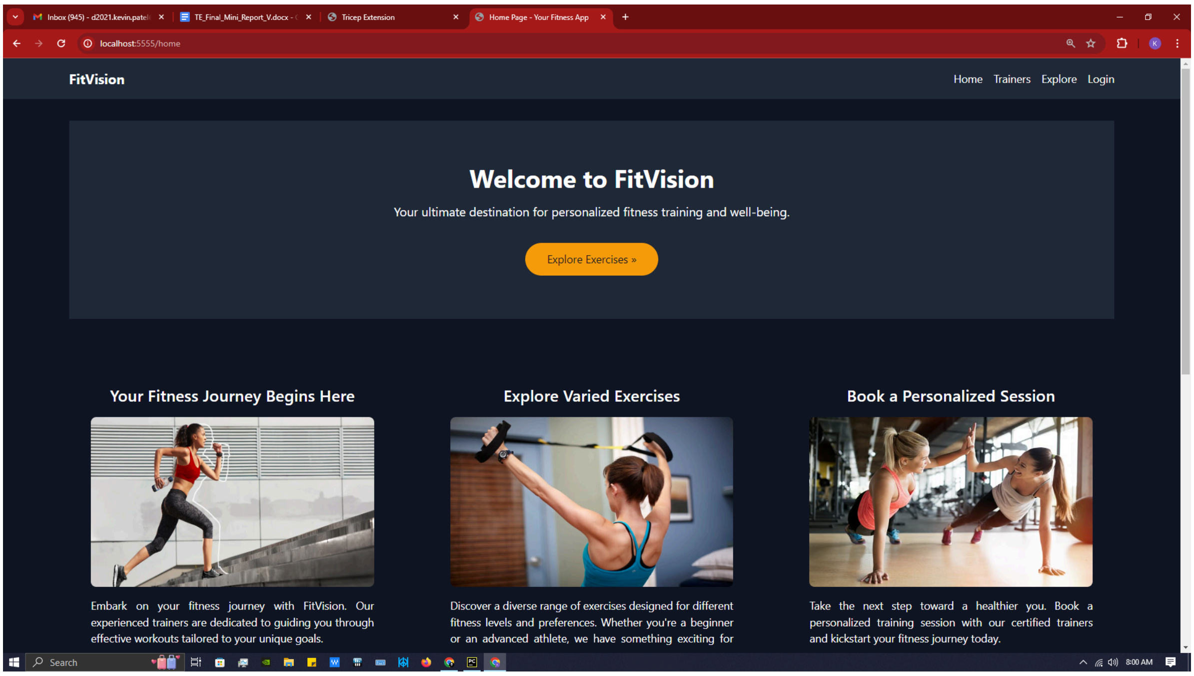

Fig 7.1.1 Home Page of System

- **Trainer Page:** The Trainer Page provides detailed profiles of the fitness trainers associated with your platform. It includes information about their expertise, experience and certifications.

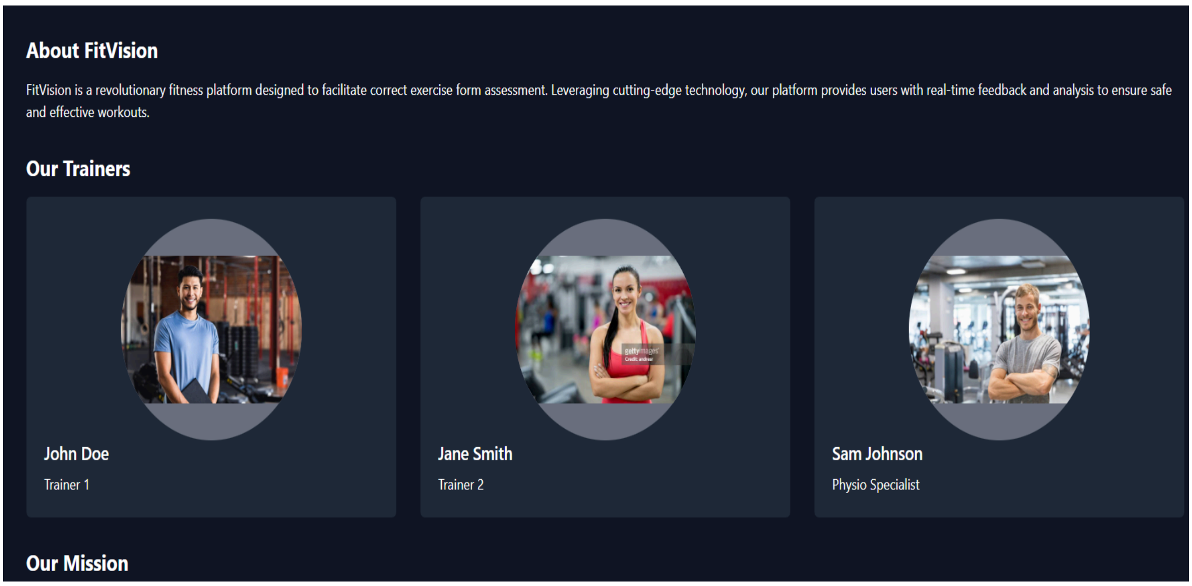

Fig 7.1.2 : Trainers page

- **Explore Page:** The explore page consists of a list of exercises.

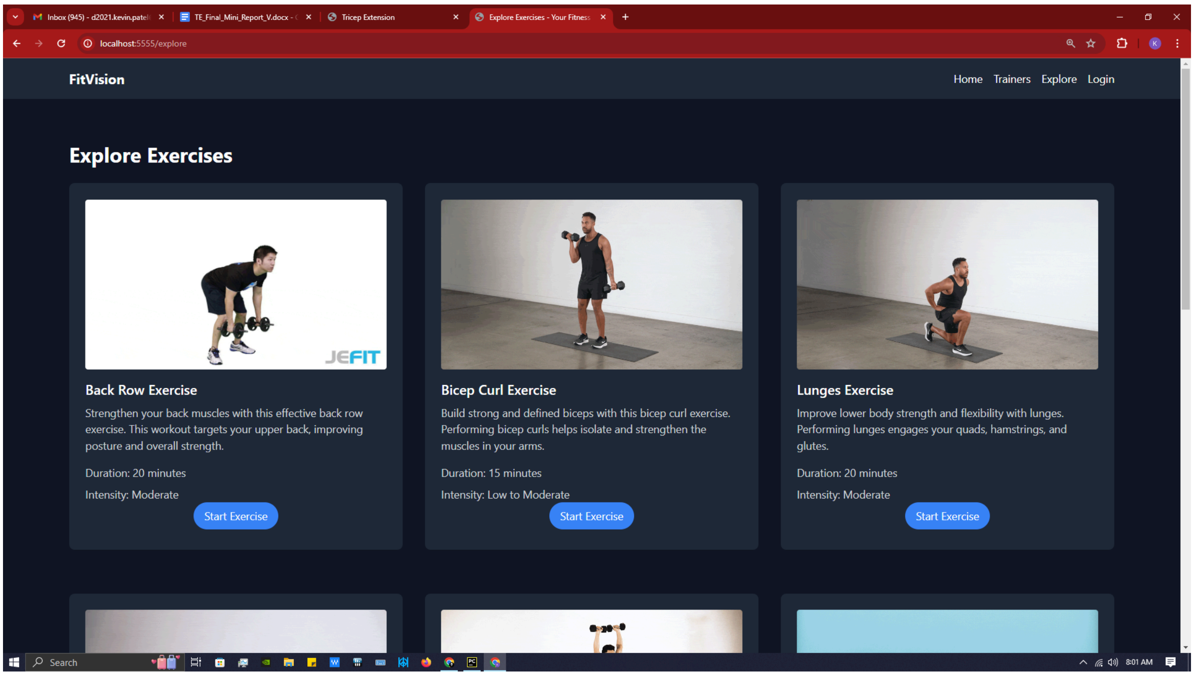

Fig 7.1.3 : Explore / Exercises Page

- **Login Page:** The Login Page allows registered users to access their accounts by entering their credentials, such as username and password.

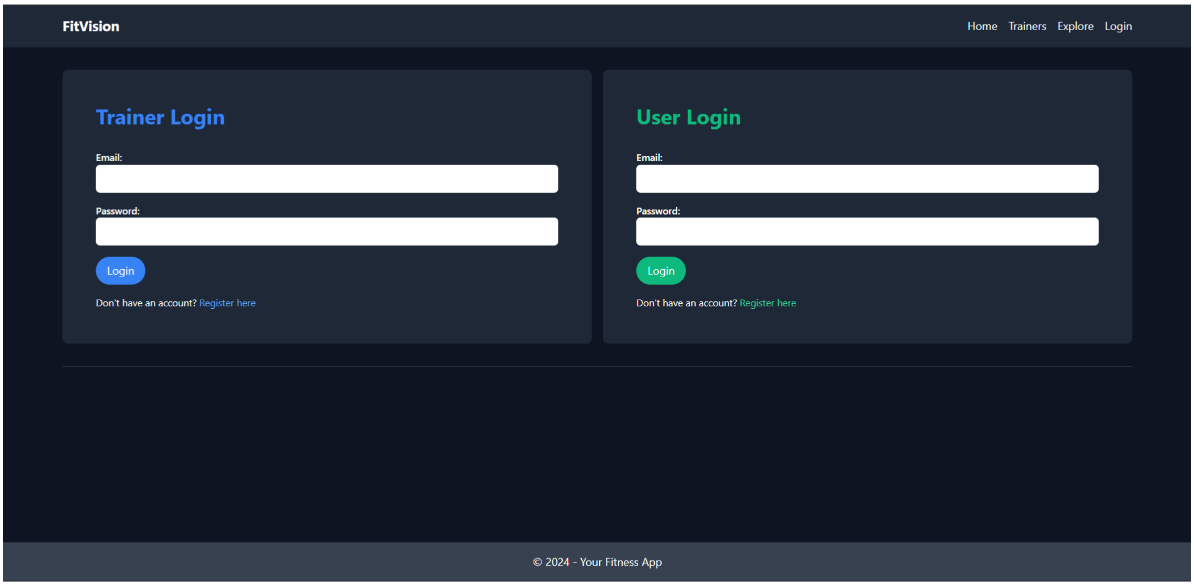

Fig 7.1.4 : Login Page

- **Booking Session Page:** The Booking Session Page allows registered users to book the session with a trainer of choice. They can select date and time and meeting link will be shared with them.

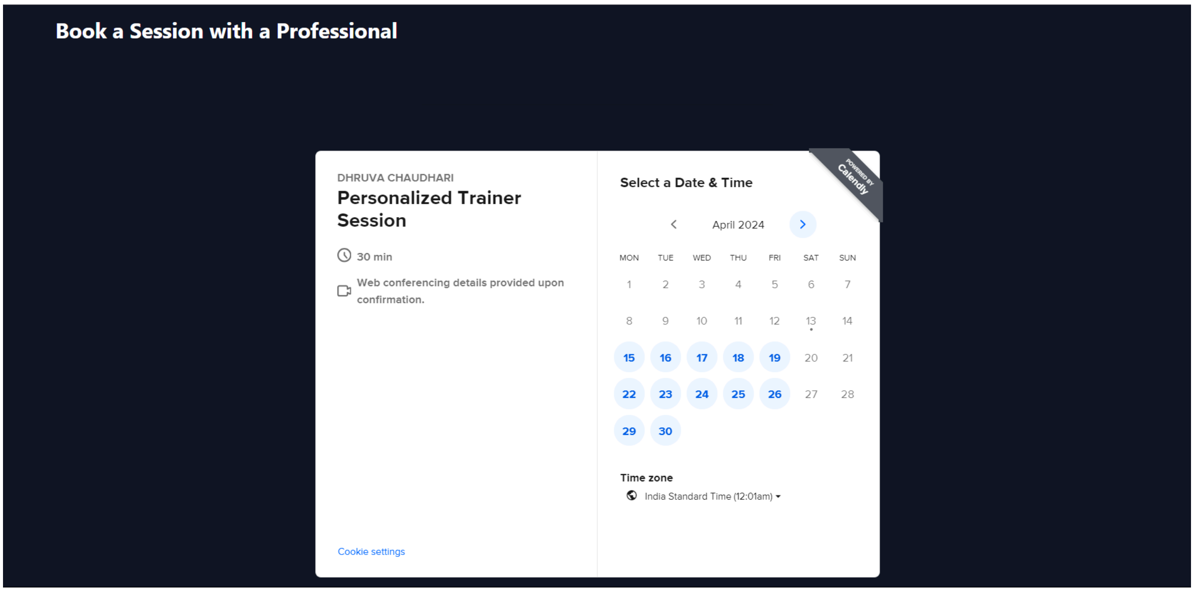

Fig 7.1.5 : Booking Session Page

- **Perform exercise Page:** This page allows users to book perform selected exercise, and would be able to determine if they need to correct their exercise form.

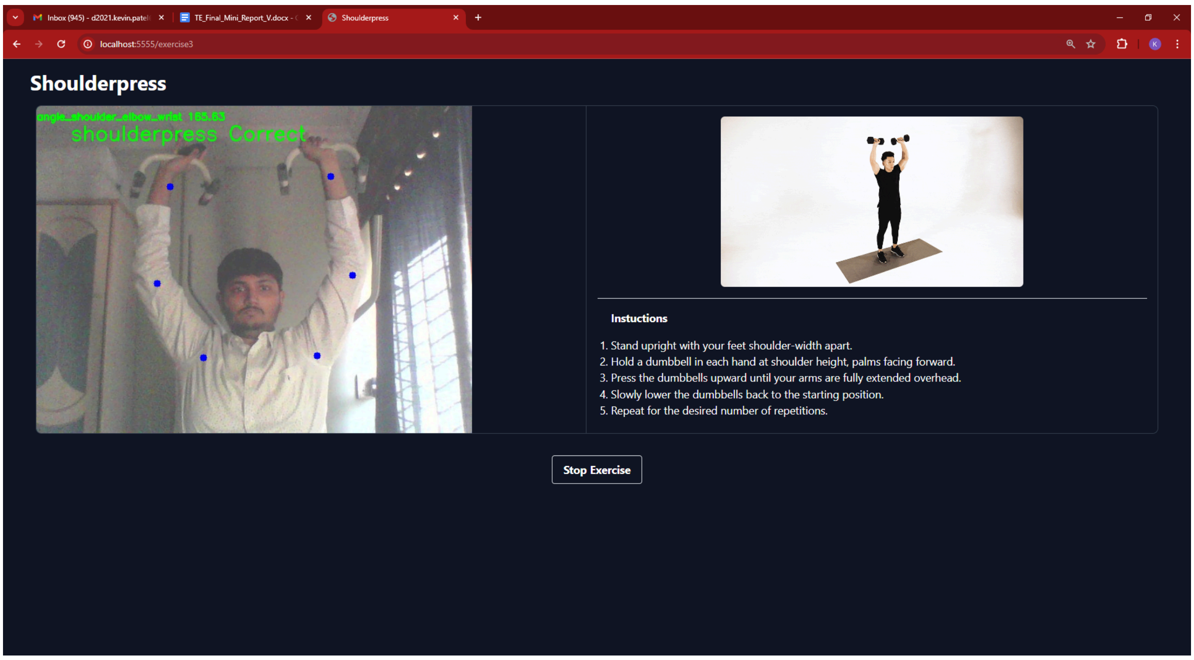

Fig 7.1.6 : Shoulder press correct form

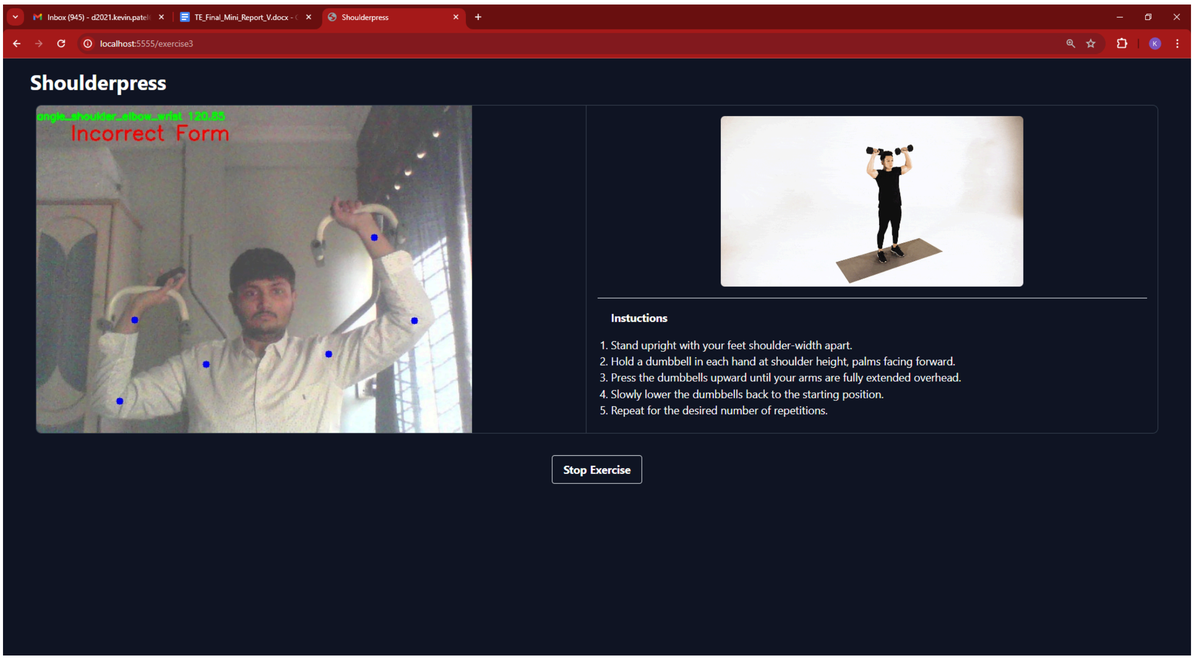

Fig 7.1.7 : Shoulder press incorrect form

7.2. User Feedback on FitVision Project

Overview:

Using a Google Form, we administered a survey to users in order to get their opinions and thoughts. The purpose of the poll was to learn about users' perceptions and experiences with FitVision, our tool for evaluating workout forms. FitVision's performance was rated in a number of areas, and participants were invited to comment on their thoughts.

Analysis of Responses:

1. Accuracy of Exercise Form Evaluation

   Most respondents gave FitVision good marks for accuracy; several gave it high marks because of its capacity to recognize little motions and offer thorough feedback.

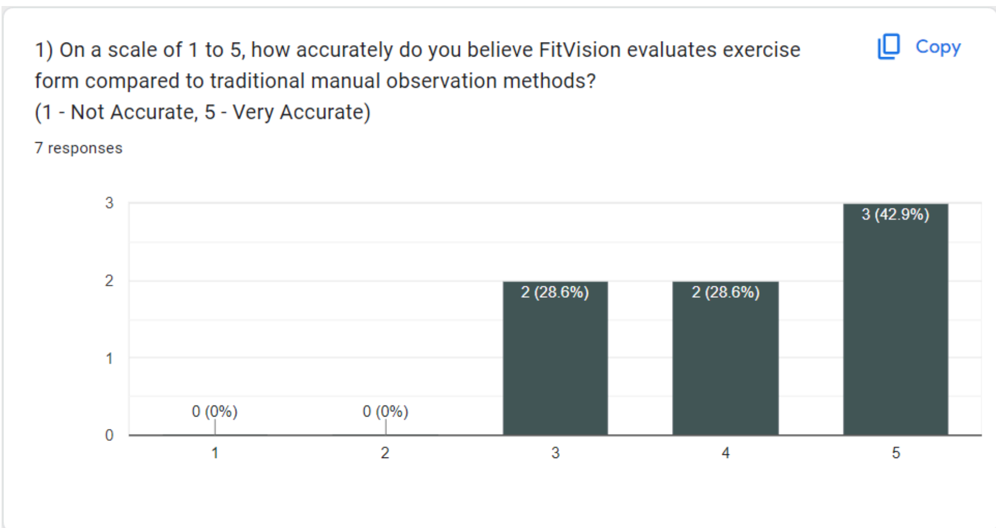

Fig 7.2.1: Accuracy of Exercise Form Evaluation

2. Consistency and Reliability

   Users appreciated the consistent feedback provided by FitVision across various exercises, allowing them to track their progress effectively and make necessary adjustments to their technique.

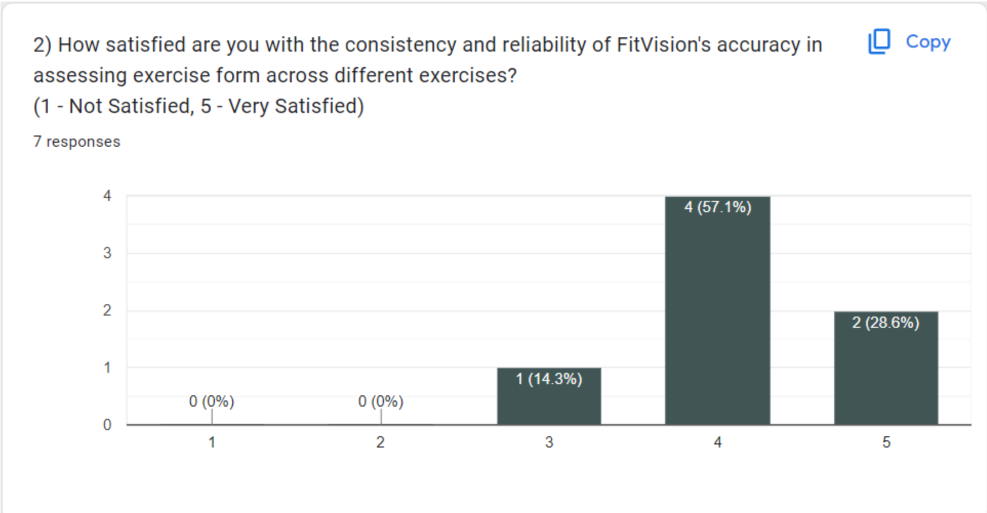

Fig 7.2.2: Consistency and Reliability

3. Handling of Occlusions

   One of the system's primary strengths was its capacity to infer the location and movement of body parts that were concealed, which allowed for accurate assessment even under difficult circumstances.

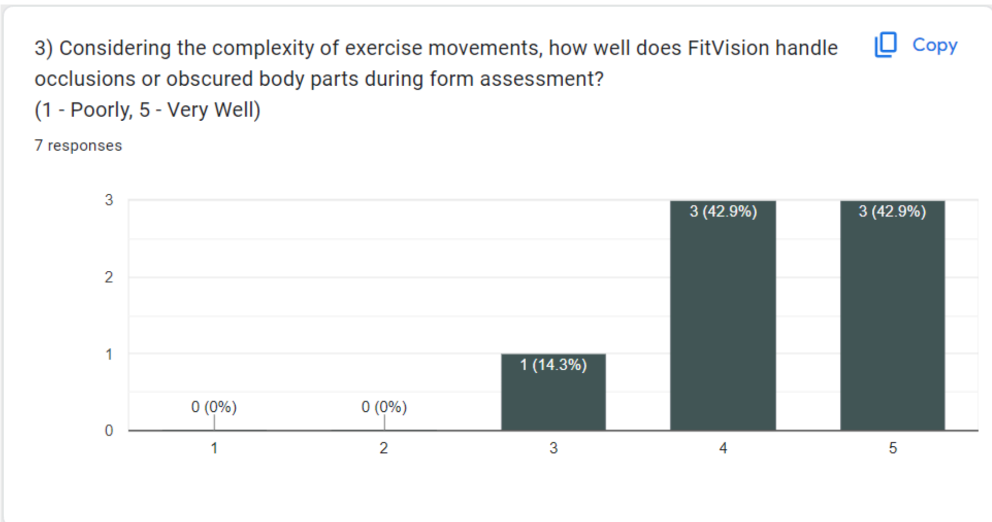

Fig 7.2.3: Handling of Occlusions

4. Level of Detail and Insights

Participants were asked to rate their satisfaction with the level of detail and insights provided by FitVision's performance evaluation measures, such as joint angles, body alignment, and posture stability

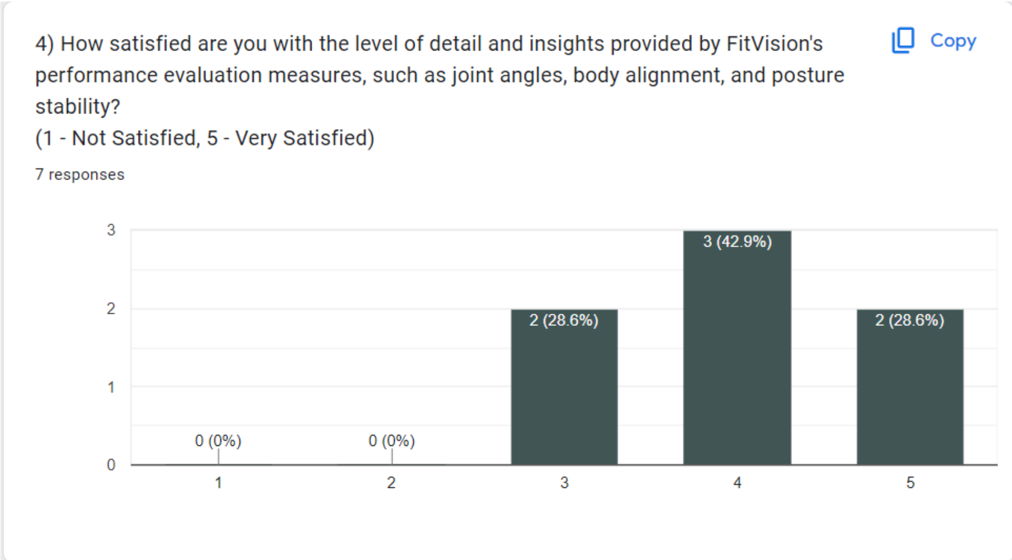

Fig 7.2.4: Level of Detail and Insights

5. Overall Satisfaction

Many users cited FitVision as a valuable tool for improving their fitness journey, praising its effectiveness and user-friendly interface.

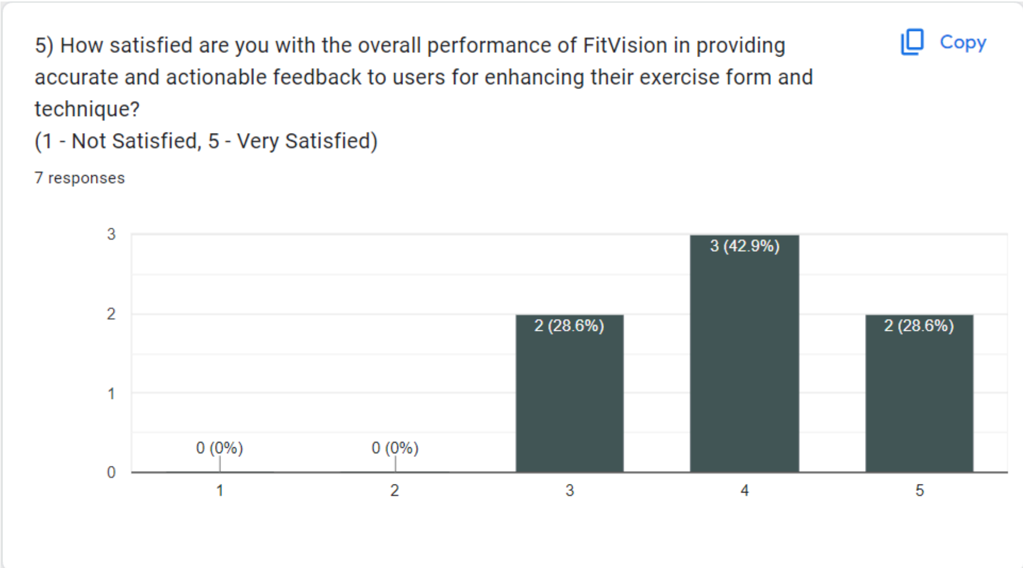

Fig 7.2.5: Overall Satisfaction

7.3. Input Parameters / Features considered

1. **Exercise Form Assessment AI Model**
    - **Form Assessment:**
        i. **Evaluation**: Pose data analysis is crucial for accurately assessing exercise form. The AI model effectively captures and analyzes joint angles, body alignment, and movement patterns to provide meaningful feedback.
    - **Real Time Video Input:**
        i. **Evaluation**: Video analysis adds an extra layer of detail, allowing the AI model to assess dynamic movements and identify subtle form deviations that may not be apparent from static pose data alone.
        ii. **Impact**: By adding video data, the model can provide more detailed feedback based on each user's performance, improving the depth of form assessment.
2. **Personalized Trainer**
    - **Evaluation**: By providing openness and trustworthiness, detailed trainer profiles help consumers make well-informed judgments based on experience, certifications, and specializations.
    - **Impact**: Carefully chosen trainer profiles build confidence and trust in users, raising the possibility of interaction and reservations.
3. **Session Booking**
    - The website's functionality and usability are improved by the session booking tool, which gives users an easy method to plan and organize their training sessions with trainers.
    - The functionality enhances user happiness and promotes a good user experience by offering proactive reminder notifications, flexible scheduling choices, and seamless integration with video conferencing solutions.
4. **Login Page:**
    - **User Authentication:**
        i. **Evaluation**: Secure user authentication protocols are essential for protecting user data and maintaining website integrity.
        ii. **Impact**: A robust authentication system instills confidence in users regarding the safety and privacy of their personal information, fostering trust and loyalty.
    - **Trainer Authentication:**

i. **Evaluation**: Only certified trainers will be allowed to access the system.
ii. **Impact**: Verified trainers have access to user data. So it ensures the safety of users' information.

7.4. Comparison of results with existing systems

The AI model uses various algorithms to assess the exercise form . The job of the algorithm is to track the body, measure angle and give inference. Among multiple pose detection algorithms we have used Mediapipe. Some of the pose detection algorithms we compared are as follows.

Framework	**OpenPose**	**MediaPipe**	**YOLOv7**	**DeepPose**
Keypoints	25	33	80	16
Accuracy	Exceptional	Good	Good	Good
Speed	Slower, several seconds	Real-time on low-powered devices	Designed for real-time	Real-time or near real-time
Hardware Requirements	Requires robust GPU	Efficient on resource-constrained devices	Can be optimized	Depends on model
Application Focus	Intricate pose estimation for various apps	Versatile across multiple vision tasks	Object detection in diverse applications	Pose estimation for healthcare, motion analysis
Model Complexity	Medium to High	Low To Medium	High	Medium to High
User - Friendliness	Moderate	High	Moderate	Moderate

Table 6: Comparative analysis of Computer Vision Frameworks

- OpenPose is one of the most accurate pose estimate frameworks available, and it is especially well-suited for applications that need complex posture analysis. Its slower processing speed and dependence on a powerful GPU, however, may make it less suitable for real-time applications.
- Conversely, MediaPipe is very efficient, especially on devices with limited resources, as it can be used for a wide range of visual tasks while maintaining good accuracy and real-time performance.
- Real-time object detection is YOLOv7's area of expertise. It has good accuracy and the ability to optimize system needs.
- With a moderate level of user-friendliness, DeepPose, which focuses on motion analysis and healthcare, gives good accuracy in real-time or nearly real-time circumstances. Every framework offers developers a variety of possibilities by

accommodating different requirements and limitations, such as those related to computing resources or application emphasis.

7.5. Inference drawn

The AI model is augmented with features like real-time video input and personalized trainer information, enhancing the overall user experience. The model accurately evaluates users' exercise form by analyzing pose data and dynamic movements, providing detailed feedback to improve performance. Additionally, the platform offers personalized trainer profiles, enabling users to make informed decisions based on trainers' experience, certifications, and specialties. This transparency builds trust and confidence among users, facilitating interaction and bookings with preferred trainers.

Moreover, the session booking tool enhances functionality and usability by allowing users to easily plan and organize their training sessions with trainers. Users can select preferred dates and times, and the platform seamlessly integrates with video conferencing solutions, ensuring a smooth experience for remote sessions. Proactive reminder notifications and flexible scheduling options further contribute to user satisfaction, promoting engagement and retention on the platform.

Comparing the AI model with existing systems, OpenPose and MediaPipe offer exceptional accuracy and real-time performance, catering to diverse application needs. YOLOv7 excels in real-time object detection, while DeepPose focuses on motion analysis and healthcare applications. Each framework addresses specific requirements and constraints, providing developers with options to optimize performance based on factors like accuracy, real-time capabilities, hardware requirements, and application focus.

Chapter 8: Conclusion

8.1 Limitations

1. **Effect of Lighting Conditions:** FitVision's performance may be significantly affected by varying lighting conditions during exercise sessions. Poor lighting or uneven illumination in workout environments can result in inaccurate pose detection and form analysis, leading to compromised feedback and user experience.
2. **Integration Complexity:** Integrating FitVision with existing fitness equipment, apps, or wearable devices may present technical complexities and interoperability challenges. Ensuring seamless integration with external systems while maintaining data integrity and user experience consistency is critical for the success of the project.
3. **Scalability and Performance:** As the user base grows, scaling the FitVision infrastructure to accommodate increased demand and workload may pose scalability challenges. Ensuring robust performance and reliability under high user traffic is essential for delivering a seamless experience to users.
4. **User Interface Accessibility:** Ensuring accessibility for users with disabilities, including visual, auditory, or motor impairments, presents a significant challenge. Designing an inclusive user interface that accommodates diverse accessibility needs while maintaining usability and functionality is essential for providing an equitable experience for all users.

8.2 Conclusion

The FitVision project represents an innovative approach to addressing the critical aspect of exercise form assessment through the integration of Artificial Intelligence and Computer Vision technologies. By leveraging these advanced technologies, FitVision aims to empower users with real-time feedback on their exercise form, personalized workout plans, and progress tracking capabilities. FitVision holds promise in revolutionizing the way individuals approach fitness and well-being. Through continuous refinement and adaptation, FitVision endeavors to enhance user experiences and promote safer and more effective exercise practices.

8.3 Future Scope

1. **Advanced Data Privacy Measures:** Implementing advanced encryption techniques and anonymization protocols can strengthen data privacy measures, ensuring compliance with evolving regulatory standards while maximizing the utilization of user-generated data for model refinement.

2. **Expanded Feature Set:** Incorporating additional features such as dietary tracking, stress management, and sleep monitoring can transform FitVision into a comprehensive health and wellness platform, catering to diverse user needs and preferences.

3. **Integration with Wearable Technology:** Integration with wearable devices for real-time biometric data monitoring and analysis can provide deeper insights into users' health and fitness metrics, enabling more personalized and adaptive workout recommendations.

4. **Community Engagement and Collaboration:** Foster community engagement through social features, user forums, and collaborative challenges to encourage peer support, knowledge sharing, and motivation among FitVision users, fostering a sense of belonging and accountability in achieving fitness goals.

By embracing these future avenues of development, FitVision can continue to evolve as a leading solution in the realm of personalized fitness and well-being, ultimately contributing to a healthier and happier society.

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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.

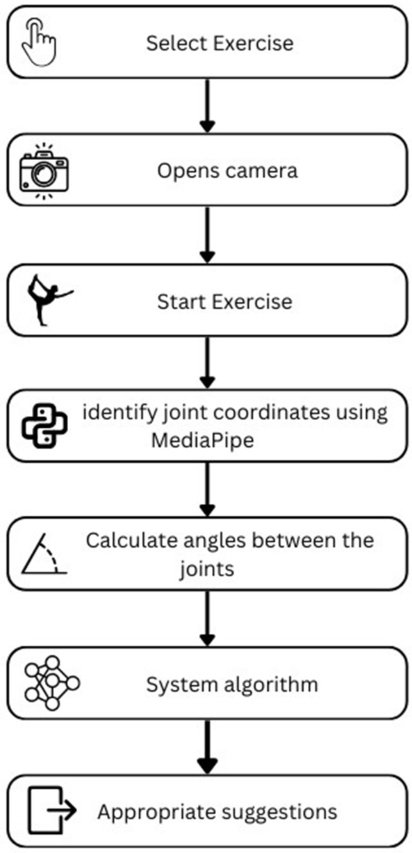

Fig 1: Process design and flow of FitVision application to achieve its functionality that includes user interactions, data processing, and the delivery of results.

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

Framework	OpenPose	MediaPipe	YOLOv7	DeepPose
Keypoints	25	33	80	16
Accuracy	Exceptional	Good	Good	Good
Speed	Slower, several seconds	Real-time on low-powered devices	Designed for real-time	Real-time or near real-time
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Application Focus	Intricate pose estimation for various apps	Versatile across multiple vision tasks	Object detection in diverse applications	Pose estimation for healthcare, motion analysis
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.

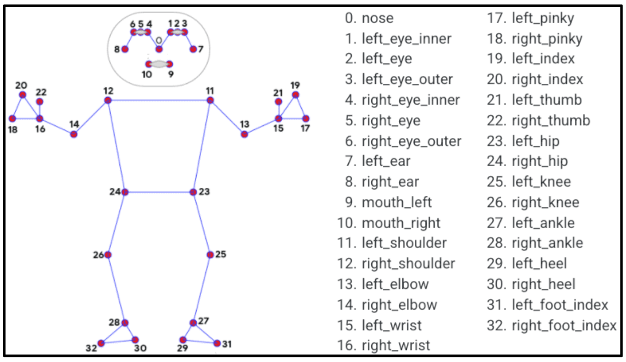

Fig 2:MediaPipe 33 landmarks on a human body model that enable pose estimation, tracking, and analysis.[8]

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

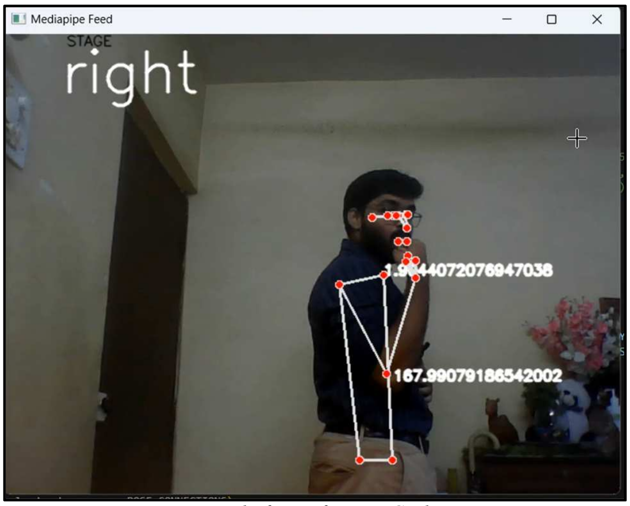

Fig 5: Right form of Bicep Curl exercise

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

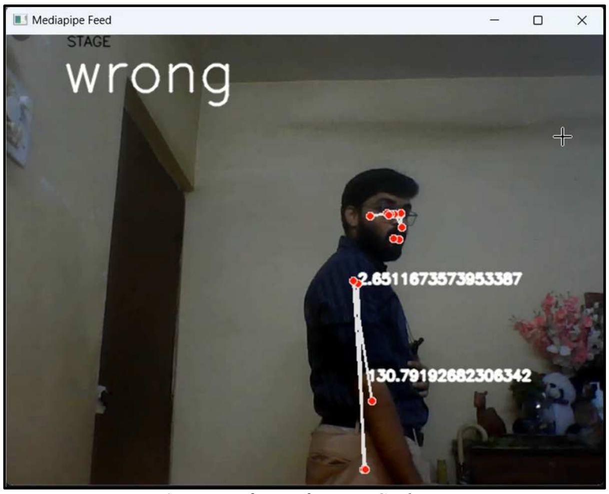

Fig 6: Wrong form of Bicep Curl exercise

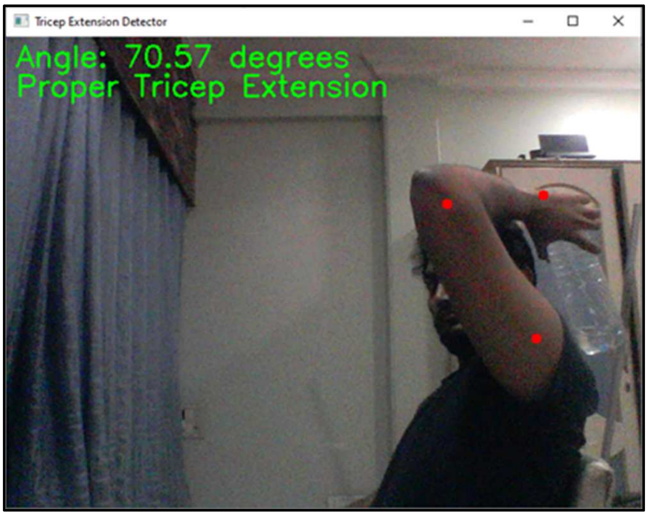

Fig 7: Calculating the angle between the points to assess the form of the one-arm tricep extension and ensure it falls within the proper threshold for an effective workout.

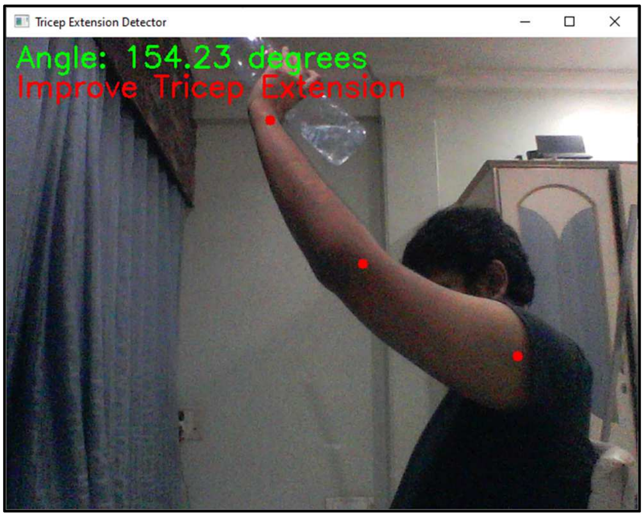

Fig 8: Checking for incorrect form by calculating the angle between the points during the one-arm tricep extension.

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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Leveraging Artificial Intelligence

by Kevin Patel

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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.

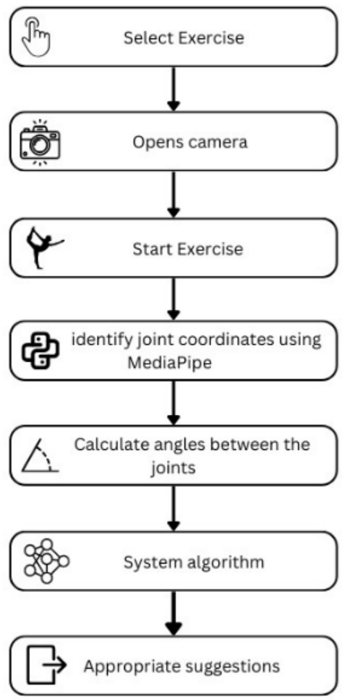

Fig 1: Process design and flow of FitVision application to achieve its functionality that includes user interactions, data processing, and the delivery of results.

TABLE I. Comparative Analysis of Computer Vision Frameworks Based on Key Criteria

Framework	OpenPose	MediaPipe	YOLOv7	DeepPose
Keypoints	25	33	80	16
Accuracy	Exceptional	Good	Good	Good
Speed	Slower, several seconds	Real-time on low-powered devices	Designed for real-time	Real-time or near real-time
Hardware Requirements	Requires robust GPU	Efficient on resource-constrained devices	Can be optimized	Depends on model
Application Focus	Intricate pose estimation for various apps	Versatile across multiple vision tasks	Object detection in diverse applications	Pose estimation for healthcare, motion analysis
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.

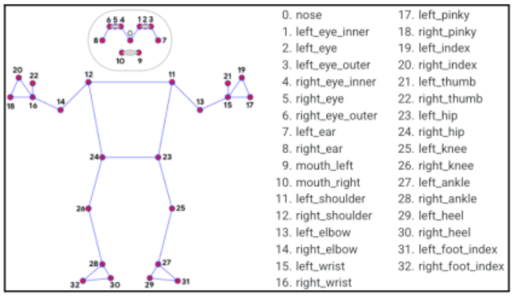

Fig 2:MediaPipe 33 landmarks on a human body model that enable pose estimation, tracking, and analysis.[8]

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

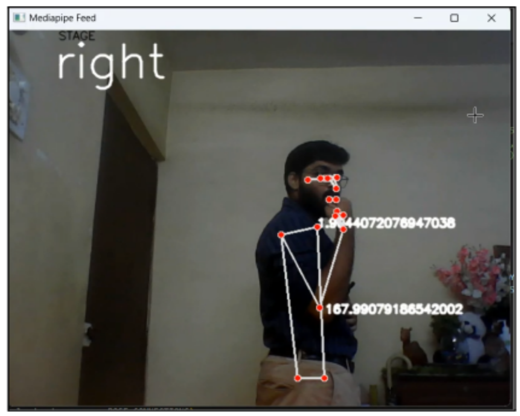

Fig 5: Right form of Bicep Curl exercise

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

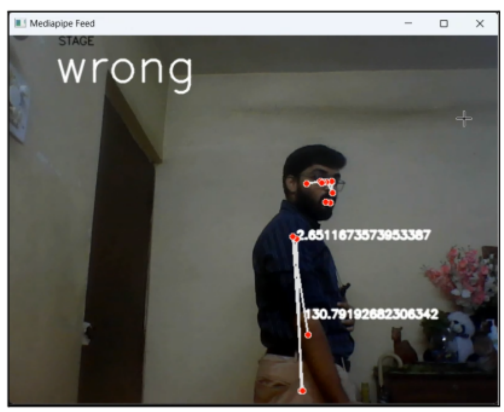

Fig 6: Wrong form of Bicep Curl exercise

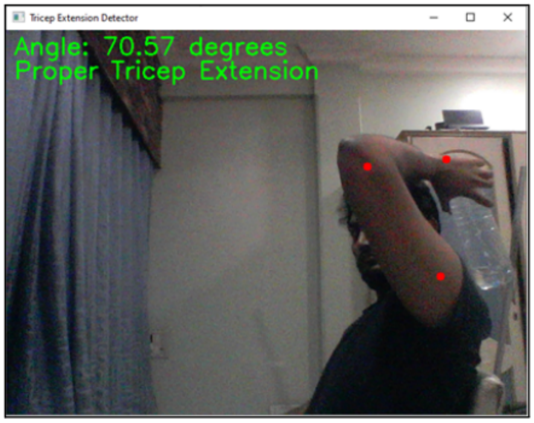

Fig 7: Calculating the angle between the points to assess the form of the one-arm tricep extension and ensure it falls within the proper threshold for an effective workout.

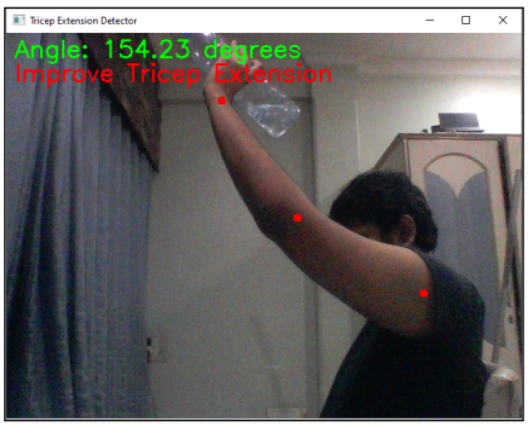

Fig 8: Checking for incorrect form by calculating the angle between the points during the one-arm tricep extension.

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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Leveraging Artificial Intelligence

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Project review sheet

Industry / Inhouse:
Research / Innovation:

Project Evaluation Sheet 2023-24 **Class: D12 A**

Title of Project (Group no): FitVision - Smart Posture Analysis for Effective Workouts - [Group No: 30]

Group Members: Kevin Patel [D12A-45] Dhruva Chaudhari [D12A - 03] MKaif Qureshi [D12A-48] Krishnam Raja [D12A - 49]

	Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environ ment Friendly (2)	Ethics (2)	Team work (2)	Presentati on Skills (3)	Applied Engg & Mgmt principles (3)	Life - long learning (3)	Profess ional Skills (5)	Innov ative Appr oach (5)	Total Marks (50)
Review of Project Stage 1	3	3	3	2	4	2	2	2	2	2	2	2	4	4	37

Comments: Integration of the modules pending,

Name & Signature Reviewer1

	Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environ ment Friendly (2)	Ethics (2)	Team work (2)	Presentati on Skills (3)	Applied Engg & Mgmt principles (3)	Life - long learning (3)	Profess ional Skills (5)	Innov ative Appr oach (5)	Total Marks (50)
Review of Project Stage 1	3	3	3	2	4	2	2	2	2	2	2	2	4	4	37

Comments: Evaluation model should be prepared.

Date: 10th February, 2024

Name & Signature Reviewer2

Inhouse/ Industry _Innovation/Research:

Sustainable Goal:

Project Evaluation Sheet 2023 - 24

Class: D12 A/~~B/C~~

Group No.: 30

Title of Project:
FitVision - Smart Posture Analysis for Effective Workouts

Group Members: Kevin Patel D12A-45 Dhruva Chaudhari D12-A -03 MKaif Qureshi D12A-48 Krishnam Raja D12A-49

Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environ ment Friendly (2)	Ethics (2)	Team work (2)	Presentati on Skills (2)	Applied Engg&M gmt principles (3)	Life - long learning (3)	Profess ional Skills (3)	Innov ative Appr oach (3)	**Resear ch Paper** (5)	**Total Marks** (50)
4	4	4	3	4	2	2	2	2	2	3	2	2	2	5	43

Comments: good work

Name & Signature Reviewer1

Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environ ment Friendly (2)	Ethics (2)	Team work (2)	Presentati on Skills (2)	Applied Engg&M gmt principles (3)	Life - long learning (3)	Profess ional Skills (3)	Innov ative Appr oach (3)	**Resear ch Paper** (5)	**Total Marks** (50)
4	4	4	3	4	2	2	2	2	2	3	2	2	2	5	43

Comments: good work

Date: 9th March, 2024

Name & Signature Reviewer 2