A Mid Term Progress Report on

REAL TIME POSTURE DETECTION

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

COMPUTER SCIENCE AND ENGINEERING

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FEB (2024)

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Chapter 1 – Introduction

In contemporary society, the prevalence of sedentary lifestyles and prolonged screen time has exacerbated the importance of maintaining proper posture. Poor posture not only leads to musculoskeletal discomfort but also contributes to longterm health issues and decreased productivity. Recognizing the critical need for proactive posture management solutions, our project endeavors to develop a sophisticated realtime posture detection system capable of assessing the correctness of human posture and providing instantaneous feedback to users. This paper presents a detailed exploration of the technological framework, user interface design, applications, challenges, and future directions of our realtime posture detection system.

Technological Framework:

The core of our realtime posture detection system lies in its robust technological framework, which integrates computer vision techniques, machine learning algorithms, and sensor data fusion. At its foundation, computer vision algorithms for human pose estimation form the backbone of posture analysis. The system accurately identifies key body landmarks and infers posture correctness from input data obtained from cameras or depth sensors.

The system's ability to process and interpret body postures in realtime hinges on the seamless fusion of sensor data. By integrating information from multiple modalities, including visual and inertial sensors, the system enhances posture estimation accuracy and robustness across diverse environments and user scenarios. Furthermore, efficient data processing techniques and optimization algorithms ensure lowlatency inference, enabling the system to deliver timely feedback on posture correctness.

User Interface and Feedback Mechanisms:

A usercentric design philosophy underscores the development of the realtime posture detection system's interface and feedback mechanisms. The user interface aims to be intuitive, engaging, and accessible to users of all demographics. Realtime feedback on posture correctness is delivered through a variety of modalities, including visual cues, audio alerts, and haptic feedback, tailored to user preferences and accessibility needs.The system provides users with actionable insights into their posture habits through personalized posture metrics, historical data trends, and performance benchmarks. Gamification elements, such as achievement badges and progress tracking, further motivate users to actively engage with the system and strive for continuous improvement in their posture habits.

Objectives:

1. RealTime Posture Detection using MediaPipe:

The primary objective of the RealTime Posture Detection System is to utilize cuttingedge technology, particularly MediaPipe, to detect human posture in realtime. By leveraging advanced computer vision algorithms and machine learning techniques, the system aims to accurately identify key body landmarks and infer posture correctness from live video streams or depth data captured by cameras or sensors.

2. Recognition of Correct Exercise Performance:

Beyond merely detecting posture, the system endeavors to recognize whether individuals are performing exercises correctly. This functionality is crucial for preventing potential injuries resulting from improper posture during physical activities and exercise routines. By providing immediate feedback on exercise form and alignment, the system empowers users to make necessary adjustments to minimize the risk of injury and optimize workout effectiveness.

3. Design of a UserFriendly Interface:

A userfriendly interface is central to the effectiveness and adoption of the RealTime Posture Detection System. The system aims to design an intuitive and interactive interface that provides realtime feedback on detected postures. Through visual cues, audio alerts, or haptic feedback mechanisms, users will receive immediate guidance and corrections to maintain proper body alignment during various activities. The interface will be tailored to accommodate users of all demographics and proficiency levels, ensuring accessibility and ease of use.

Applications and Benefits:

The realtime posture detection system has farreaching applications across various domains, including healthcare, workplace ergonomics, fitness training, and rehabilitation. In healthcare settings, the system serves as a valuable tool for monitoring and managing posturerelated ailments, facilitating early intervention and preventive care strategies. In workplace environments, employers can leverage the system to promote employee wellness, prevent musculoskeletal injuries, and optimize ergonomic workstations.

Moreover, the system empowers individuals to take proactive measures to improve their posture habits and enhance their overall quality of life. By providing realtime feedback and

personalized recommendations, the system fosters a culture of posture awareness and selfcare, empowering users to make informed choices about their health and wellbeing.

Challenges and Future Directions:

Despite the advancements in realtime posture detection technology, several challenges remain to be addressed. Ensuring robustness to environmental factors, adaptability to diverse body types and clothing styles, and scalability for realworld deployment are among the key challenges facing the development and implementation of the system. Additionally, addressing privacy concerns, data security, and regulatory compliance will be paramount to building trust and confidence among users and stakeholders.

Looking ahead, future iterations of the realtime posture detection system may explore advancements in sensor technology, multimodal data fusion, and personalized feedback algorithms to further enhance accuracy, reliability, and user engagement. Collaborative research efforts, interdisciplinary collaborations, and usercentered design principles will be instrumental in driving innovation and advancing the stateoftheart in posture management solutions.

Chapter 2 System Requirements

Hardware Requirements:

Camera or Depth Sensor: A highresolution camera or depth sensor capable of capturing clear images or depth data of the user's body posture is essential. The camera should have sufficient frame rate and resolution to enable accurate pose estimation in realtime.

Processor:

A powerful processor capable of handling computationally intensive tasks is necessary for realtime pose estimation. Multicore processors, such as Intel Core i7 or AMD Ryzen processors, are recommended to ensure smooth operation and lowlatency inference.

Graphics Processing Unit (GPU):

A dedicated GPU with CUDA support is highly recommended for accelerating deep learning inference tasks. GPUs from NVIDIA, such as GeForce GTX or RTX series, significantly enhance the performance of deep learning models, reducing inference times and improving overall system responsiveness.

Memory (RAM):

Sufficient RAM is crucial for storing and processing large datasets during model training and inference. A minimum of 8 GB of RAM is recommended for optimal performance, although higher capacities may be beneficial for handling larger datasets and multitasking.

Storage:

Adequate storage capacity is required for storing datasets, model weights, and software dependencies. Solidstate drives (SSDs) offer faster read/write speeds compared to traditional hard disk drives (HDDs), resulting in quicker data access and model loading times.

Software Requirements:

Operating System: The choice of operating system depends on the compatibility of software libraries and frameworks used in the realtime posture detection model. Common options include Windows, Linux (e.g., Ubuntu), and macOS.

Development Environment:

A comprehensive development environment is necessary for coding, training, and testing the realtime posture detection model. Popular integrated development environments (IDEs) such as PyCharm, Visual Studio Code, or Jupyter Notebook provide features for code editing, debugging, and version control.

Python Programming Language:

Python serves as the primary programming language for developing realtime posture detection models due to its versatility, extensive libraries, and community support. Ensure that Python is installed along with package managers such as pip or Anaconda for managing software dependencies.

Computer Vision Libraries:

Computer vision libraries such as OpenCV (Open Source Computer Vision Library) provide essential functions for image processing, feature extraction, and pose estimation. Integrating OpenCV with deep learning frameworks enables seamless integration of computer vision algorithms into the realtime posture detection pipeline.

Additional Libraries and Dependencies:

Depending on specific requirements, additional libraries and dependencies may be needed for data preprocessing, visualization, and performance evaluation. Common libraries include NumPy, SciPy, Matplotlib, mediapipe and scikitlearn for scientific computing and machine learning tasks.

Documentation and Version Control:

Comprehensive documentation and version control tools such as Git and GitHub facilitate collaboration, code management, and reproducibility of experiments. Maintain detailed documentation of code structure, model architecture, and training procedures to ensure transparency and facilitate future enhancements.

By ensuring compatibility with the specified hardware and software requirements, the realtime posture detection model can be effectively developed, deployed, and maintained for various applications and use cases.

Chapter 3 - Software Requirement Analysis

3.1 Problem Definition:

The primary objective of the realtime posture detection system is to accurately analyze human body postures from live video streams or depth data captured by cameras or sensors. The system must identify key body landmarks, assess posture correctness based on predefined criteria, and provide immediate feedback to users. To achieve this, the software architecture must encompass a series of interconnected modules, each fulfilling specific functions within the posture detection pipeline.

3.2 Software Modules and Their Functionality:

app.py:

app.py serves as the entry point for the web application built to facilitate realtime posture detection and exercise monitoring. It leverages the Flask framework to create a userfriendly interface accessible through a web browser. Below are the key components and functionalities of app.py:

1. Initialization:

Imports necessary modules and libraries required for the application, including Flask and the Video Stream module.

Initializes the Flask application instance.

2. Routes:

Defines route handlers for different endpoints of the web application, such as the home page and video feed.

Specifies the actions to be taken when a user accesses each route, including rendering HTML templates and streaming video content.

3. User Interface:

Renders HTML templates to provide a graphical user interface (GUI) for interacting with the application.

Includes buttons, forms, and other UI elements to allow users to select exercise modes, view video streams, and receive feedback on their posture and exercise performance.

4. Integration with VideoStream Module:

Instantiates a VideoStream object to capture live video streams from the user's camera.

Sets up the connection between the Flask application and the VideoStream module to stream video content to the web interface.

5. User Interaction:

Enables user interaction by processing HTTP requests and triggering appropriate actions, such as changing exercise modes or displaying exercise feedback.

Implements logic to handle user input and update the application state accordingly.

6. Error Handling:

Includes error handling mechanisms to gracefully handle exceptions and display error messages to users if any unexpected issues occur during application execution.

7. Deployment:

Specifies configurations for running the Flask application, including host, port, and debug mode settings.

Provides instructions for deploying the application on different platforms or servers.

VideoStream Module:

The videostream module is responsible for capturing live video streams from the user's camera, processing the video frames to detect human poses, and providing realtime feedback on posture and exercise performance. Here's an overview of its functionality:

1. Camera Initialization:

Utilizes OpenCV (cv2) to access the user's camera and initialize video capture.

2. Integration with Pose Detection:

Integrates with a pose detection module (not explicitly mentioned) to analyze video frames and detect human poses in realtime.

Utilizes computer vision techniques to identify key body landmarks and joints, such as shoulders, elbows, hips, knees, and ankles.

3. Exercise Classification:

Includes modules or algorithms for classifying specific exercises or yoga poses performed by the user, such as pushups, planks, or tree poses.

Analyzes the alignment, movement, and form of the user's body during exercises to

determine correctness and provide feedback.

4. Realtime Feedback:

Provides realtime feedback to users on their posture, exercise technique, and performance.

Renders visual cues or overlays on the video feed to indicate correct or incorrect posture and offer guidance for improvement.

5. Streaming Video Content:

Streams processed video frames with overlays and feedback to the web application via Flask's streaming response mechanism.

Encodes video frames into JPEG format and sends them as multipart responses for seamless video playback in the browser.

6. User Interaction:

Enables user interaction by allowing users to select exercise modes, view video streams, and receive feedback through the web interface.

Processes user input from the web application to update the exercise mode or adjust the feedback provided during video streaming.

Pose Detector:

Responsible for capturing live video streams from webcams or cameras.

Utilizes computer vision techniques to detect human body poses and landmarks in realtime.

Identifies key anatomical landmarks and joints, such as shoulders, elbows, hips, knees, and ankles.

Provides a foundational dataset for subsequent modules to analyze and interpret user movements and postures accurately.

Pushup Classifier:

Specialized module designed to recognize and evaluate pushup exercises performed by the user.

Analyzes the alignment and movement of the user's body during pushups, focusing on elbow angles, shoulder positioning, and overall form.

Utilizes machine learning algorithms to classify pushup repetitions as either correct or incorrect based on predefined criteria.

Provides instant feedback on pushup performance, including the number of repetitions

completed and the quality of each repetition.

Bicep Classifier:

Module dedicated to detecting and assessing bicep curl exercises executed by the user.

Tracks the motion of the user's arms and elbows during bicep curls, emphasizing proper range of motion and form.

Applies pattern recognition algorithms to differentiate between correct and incorrect bicep curl techniques.

Offers realtime feedback on bicep curl execution, helping users maintain proper form and maximize workout effectiveness.

Plank Classifier:

Specialized module designed to identify and evaluate plank poses assumed by the user.

Analyzes the alignment of the user's body during the plank exercise, focusing on core stability, spinal alignment, and shoulder positioning.

Utilizes machine learning models to classify plank poses as either correctly or incorrectly performed based on established criteria.

Delivers immediate feedback on plank form and duration, assisting users in maintaining proper posture and achieving optimal results.

Tree Classifier:

Module dedicated to recognizing and assessing tree yoga poses practiced by the user.

Tracks the positioning of the user's legs, arms, and torso during the tree pose, emphasizing balance, alignment, and stability.

Applies pattern recognition techniques to distinguish between correct and incorrect tree pose variations.

Provides realtime feedback on tree pose execution, guiding users toward improved balance and concentration.

Tpose Classifier:

Module focused on detecting and evaluating Tpose positions assumed by the user.

Monitors the alignment and symmetry of the user's arms, shoulders, and spine during the Tpose stance.

Utilizes machine learning algorithms to classify Tpose variations as either correctly or incorrectly executed.

Offers immediate feedback on Tpose form and alignment, assisting users in achieving proper posture and muscle engagement.

Warrior Classifier:

Specialized module designed to recognize and assess warrior yoga poses performed by the user.

Tracks the positioning of the user's legs, arms, and torso during warrior pose variations, emphasizing strength, flexibility, and balance.

Applies pattern recognition algorithms to differentiate between correct and incorrect warrior pose techniques.

Delivers realtime feedback on warrior pose execution, guiding users toward improved posture and mindfulness.

Chapter 4 – Software Design

Flowchart

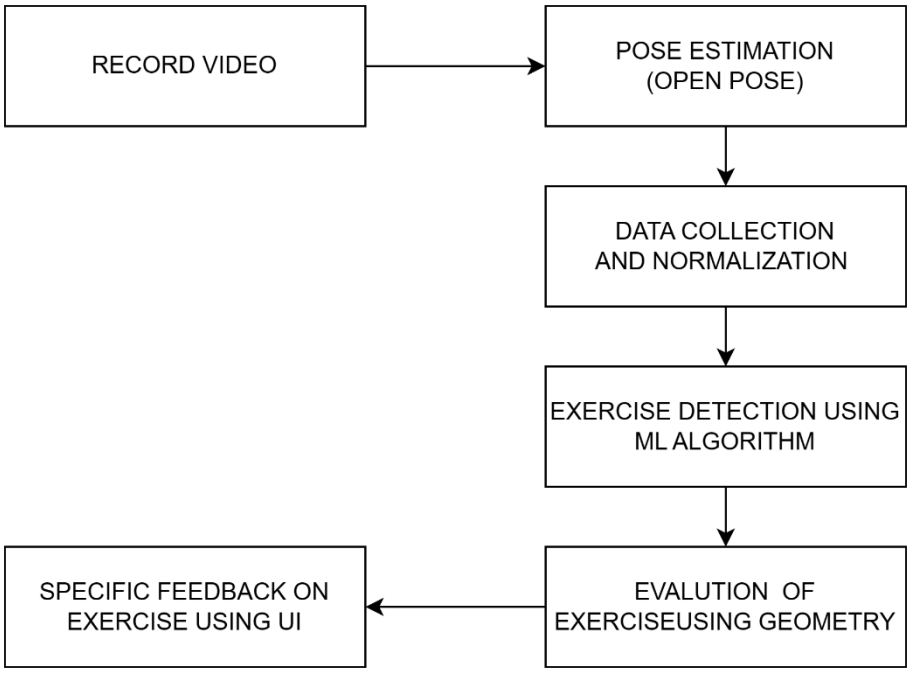

Fig 4.1- Flowchart

Recording video:

1. Preprocessing: Before inputting the video into OpenPose, consider preprocessing steps like background subtraction or denoising to improve accuracy.
2. Multiple Views: For more accurate posture estimation, capture video from multiple angles *if* possible (front, side, back).
3. Calibration: If using sensors, ensure proper calibration for reliable data capture.

OpenPose:

1. Keypoint Selection: Specify which body keypoints are relevant for your specific posture analysis (e.g., joints, head, limbs).
2. Tracking: Implement mechanisms to track keypoints across consecutive frames for smooth pose estimation.
3. Error Handling: Incorporate error handling for occlusion, missing keypoints, or low confidence scores.

Data Processing and Analysis:

1. Feature Extraction: Extract relevant features from keypoint data, such as angles, distances, ratios, or temporal changes.
2. Filtering: Apply filters to smooth noisy data or focus on specific aspects of posture (e.g., lowpass filter for overall posture, moving average filter for tremor analysis).
3. Normalization: Normalize extracted features to a common scale for machine learning algorithms.

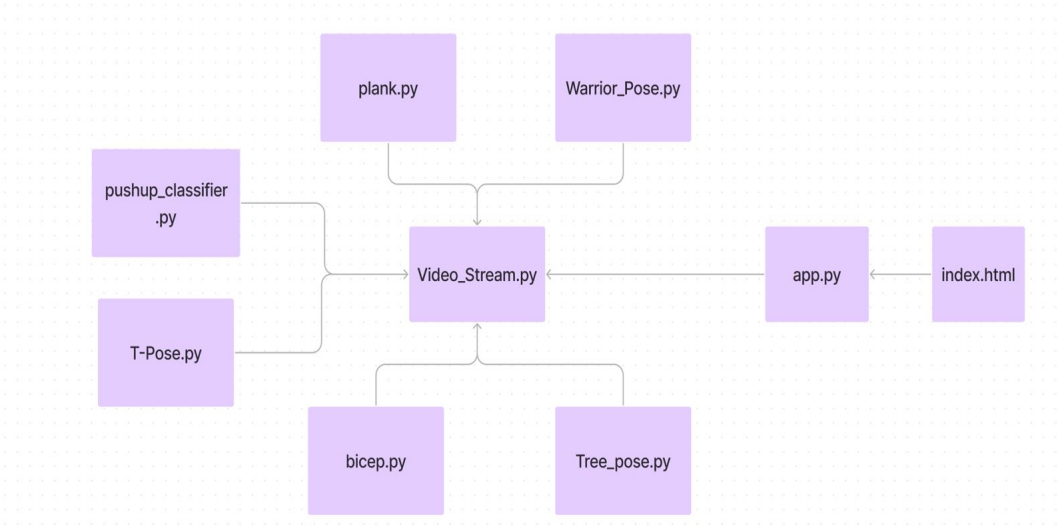

Fig 4.2 Classes and Module Interaction

Machine Learning:

1. Model Selection: Choose an appropriate machine learning model based on your task (e.g., classification for specific postures, regression for continuous values).
2. Training Data: Prepare highquality labeled training data with diverse postures and variations.
3. Evaluation: Evaluate the model's performance using metrics like accuracy, precision, recall, or F1score.

Feedback and Evaluation:

1. Feedback Mechanism: Design visual or auditory feedback based on the ML output, emphasizing specific posture corrections.
2. Adaptability: Consider adapting feedback based on user progress or individual needs.
3. Geometric Evaluation: Calculate additional metrics like range of motion, symmetry, or joint

angles for detailed analysis.

4. Realtime Performance: Ensure efficient computation and communication for responsive feedback in realtime scenarios.

Chapter 5 – Testing Module

The testing module aims to validate the functionality, accuracy, and stability of the realtime posture detection system implemented in the provided code. The system utilizes computer vision techniques for posture detection and classification of various exercises.

1. Purpose and Scope:

The testing module covers a range of test cases to ensure the following:

Accuracy of the posture classifiers.

Accuracy of the pose detection algorithm.

Stability of the system under continuous operation.

Correct functionality of classifier selection.

2. Environment Setup

Dependencies and Requirements:

OpenCV library for video processing.

Flask for streaming video frames.

Angle Calculator module for angle calculations.

Classifier modules (Pushup Classifier, Bicep Classifier, etc.).

Pose Detector module for pose detection.

Configuration for Testing Environment:

Test environment should have access to a webcam or camera for video input.

Ensure all dependencies and required modules are installed and properly configured.

3. Test Cases

3.1. Classifier Testing

Test Case 1: Pushup Classifier Accuracy

Description: Test the accuracy of the pushup classifier.

Steps:

Prepare a set of images/videos with pushup poses.

Feed the images/videos into the pushup classifier.

Verify if the classifier accurately detects pushup poses.

Test Case 2: Bicep Classifier Accuracy

Description: Test the accuracy of the bicep classifier.

Steps: (similar to Test Case 1)

Test Case 3: Plank Classifier Accuracy

Description: Test the accuracy of the plank classifier.

Steps: (similar to Test Case 1)

Test Case 4: Tree Classifier Accuracy

Description: Test the accuracy of the tree classifier.

Steps: (similar to Test Case 1)

Test Case 5: TPose Classifier Accuracy

Description: Test the accuracy of the TPose classifier.

Steps: (similar to Test Case 1)

Test Case 6: WarriorPose Classifier Accuracy

Description: Test the accuracy of the WarriorPose classifier.

Steps: (similar to Test Case 1)

3.2. Pose Detection Testing

Test Case 7: Pose Detection Accuracy

Description: Test the accuracy of the pose detection algorithm.

Steps:

Provide sample images/videos with various poses.

Analyze the accuracy of the pose detection by comparing detected poses with ground truth.

3.3. System Integration Testing

Test Case 8: System Stability Test

Description: Test the stability of the system under continuous operation.

Steps:

Run the realtime posture detection system for an extended period.

Monitor for any memory leaks, crashes, or performance issues.

Test Case 9: Classifier Selection Test

Description: Test the functionality of selecting different classifiers.

Steps:

Set different classifiers for the VideoStream object.

Verify if the system adapts and uses the selected classifier appropriately.

4. Test Results and Analysis

Record the results of each test case.

Document any discrepancies or issues encountered during testing.

Provide insights and analysis of the test outcomes.

5. Conclusion

Summary of Testing:

Summarize the overall testing process and outcomes.

Highlight any areas for improvement or further testing.

CHAPTER 6 - Performance of Project developed so far

1. Introduction

The performance evaluation of the developed project encompasses various aspects critical to its effectiveness, reliability, and user satisfaction. In this report, we delve into the intricacies of pose detection accuracy, classifier performance, real time processing capabilities, user interface responsiveness, scalability, resource utilization, robustness, error handling, testing, and validation procedures.

2. Accuracy of Pose Detection

Pose detection accuracy serves as the cornerstone of the project, facilitating the recognition of human body poses during workout sessions. The MediaPipe library, renowned for its robustness in pose estimation, forms the backbone of our pose detection system. To assess accuracy, we meticulously evaluate landmark detection across diverse lighting conditions, camera angles, and user poses. Robust pose detection ensures the reliability of subsequent classification tasks.

3. Classifier Performance

Classifiers play a pivotal role in recognizing specific workout poses based on the positions of body landmarks detected by the pose estimation system. Angle calculations between body landmarks serve as fundamental features for classifier training and inference. The performance of classifiers is rigorously tested using a diverse set of workout poses, encompassing variations in body types, clothing, and environmental factors.

4. Realtime Processing

Realtime processing capability is paramount for providing instantaneous feedback to users during their workout sessions. It entails efficient frame processing, pose detection, and classification within stringent time constraints to maintain a responsive user experience. Latency, the delay between performing a movement and receiving feedback, is minimized through optimized algorithms and parallel processing techniques. Realtime processing performance is assessed through latency measurements and frame rate analysis under varying workload conditions.

5. User Interface (UI) Responsiveness

UI responsiveness is indispensable for ensuring smooth and intuitive user interactions with the application interface. Seamless video streaming, quick classifier selection, and responsive controls enhance user engagement and satisfaction. UI responsiveness is evaluated across different devices and network conditions, encompassing usability testing, interface design evaluations, and user feedback analysis. Performance metrics include response time, error rates, and user satisfaction scores obtained through surveys and usability studies.

6. Scalability and Extensibility

Scalability and extensibility are essential attributes of the project architecture, enabling it to accommodate increased workload and seamlessly integrate additional features. The modular design facilitates the integration of new classifiers, pose detection models, or algorithmic improvements without disrupting existing functionalities. Scalability is evaluated through stress testing and performance profiling, while extensibility is assessed based on the ease of system modification and feature expansion.

7. Resource Utilization

Efficient resource utilization is critical for optimizing CPU, memory, and other system resources while meeting performance requirements. Resource monitoring and profiling tools are employed to identify performance bottlenecks, optimize resource allocation, and minimize overhead. Performance metrics include CPU utilization, memory consumption, and I/O throughput, providing insights into resource usage patterns and system performance under varying workloads.

8. Robustness and Error Handling

Robust error handling mechanisms are imperative for maintaining system stability and preventing application crashes. Graceful handling of errors and exceptions, such as pose detection failures or classifier errors, ensures uninterrupted user experience and prevents data loss.

9. Testing and Validation

Testing and validation procedures are integral to verifying the correctness, reliability, and performance of the system. Test cases cover various use cases, edge cases, and boundary conditions, ensuring comprehensive validation of system functionality. Validation

procedures encompass unit testing, integration testing, system testing, and user acceptance testing, culminating in the verification of system robustness and reliability.

10. Conclusion

In conclusion, the performance evaluation of the developed project encompasses a multifaceted analysis of pose detection accuracy, classifier performance, realtime processing capabilities, UI responsiveness, scalability, resource utilization, robustness, error handling, testing, and validation procedures. Through meticulous evaluation and iterative refinement, we ensure the effectiveness, reliability, and user satisfaction of the developed project, fostering continuous improvement and innovation in the field of human pose detection and activity recognition.

CHAPTER 7 OUTPUT SCREEN

1. Main screen:-

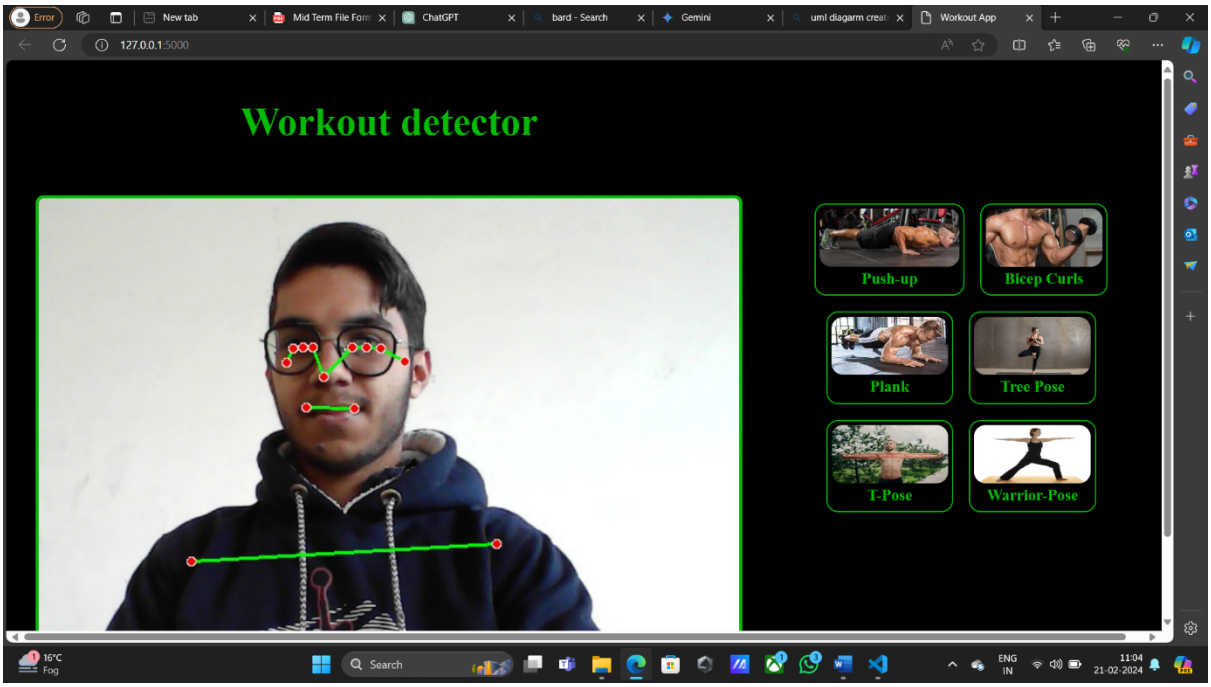

Fig 7.1 – User Interface

2.Push Up:-

Fig 7.2- Push up classifier

3. Bicep pose:-

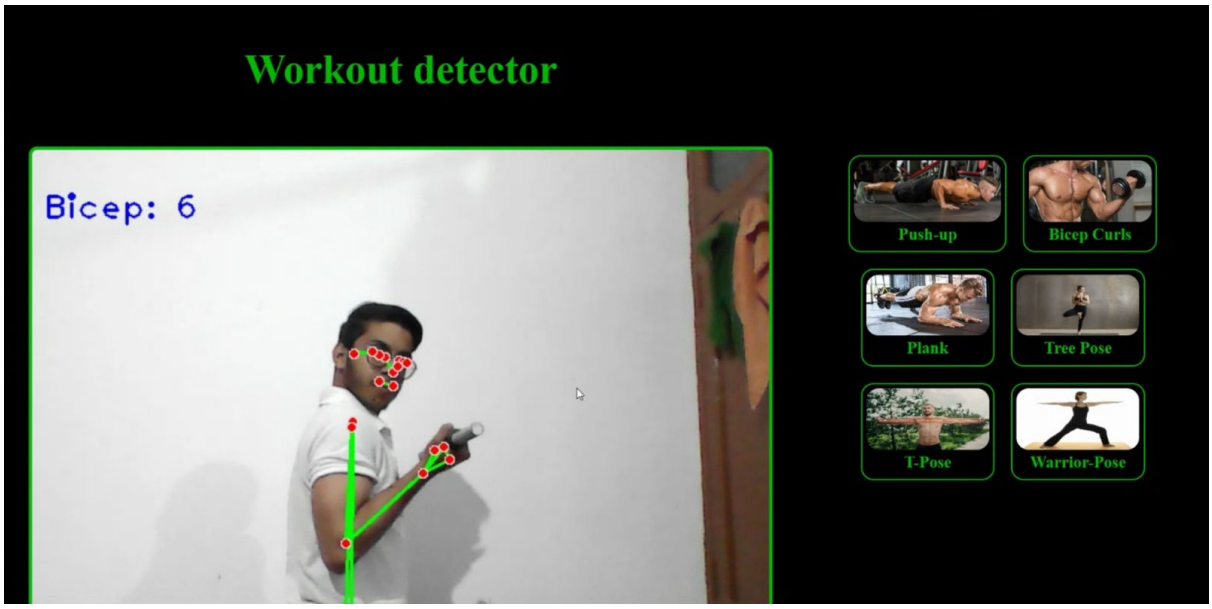

Fig 7.3 Bicep pose

4.T-POSE:-

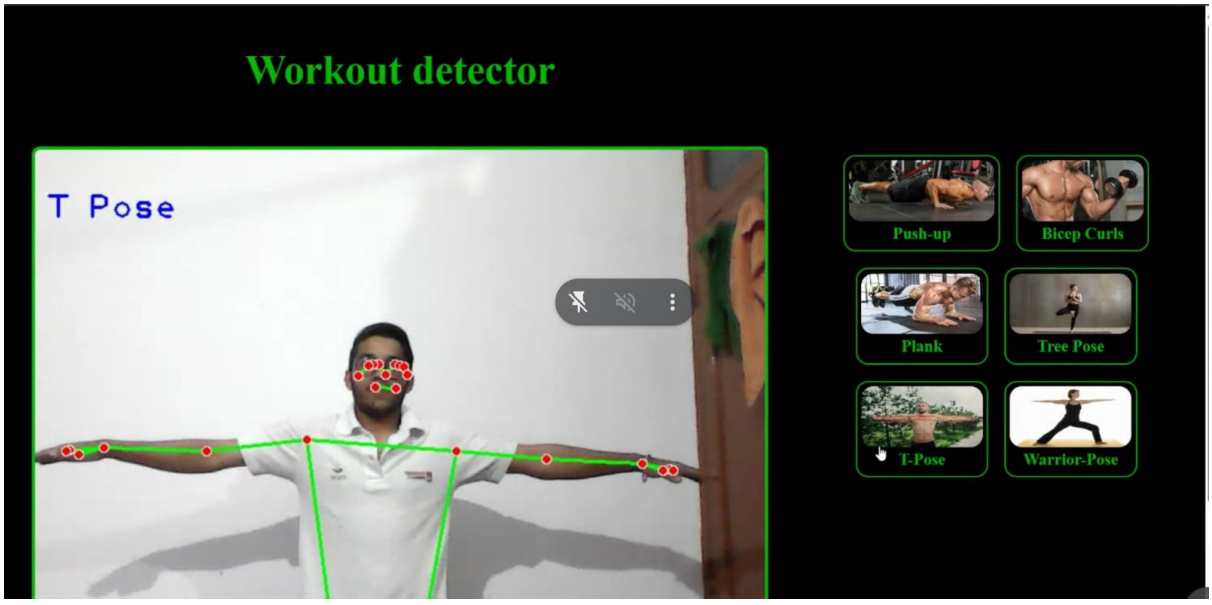

Fig 7.4- T Pose

5.TREE-POSE:-

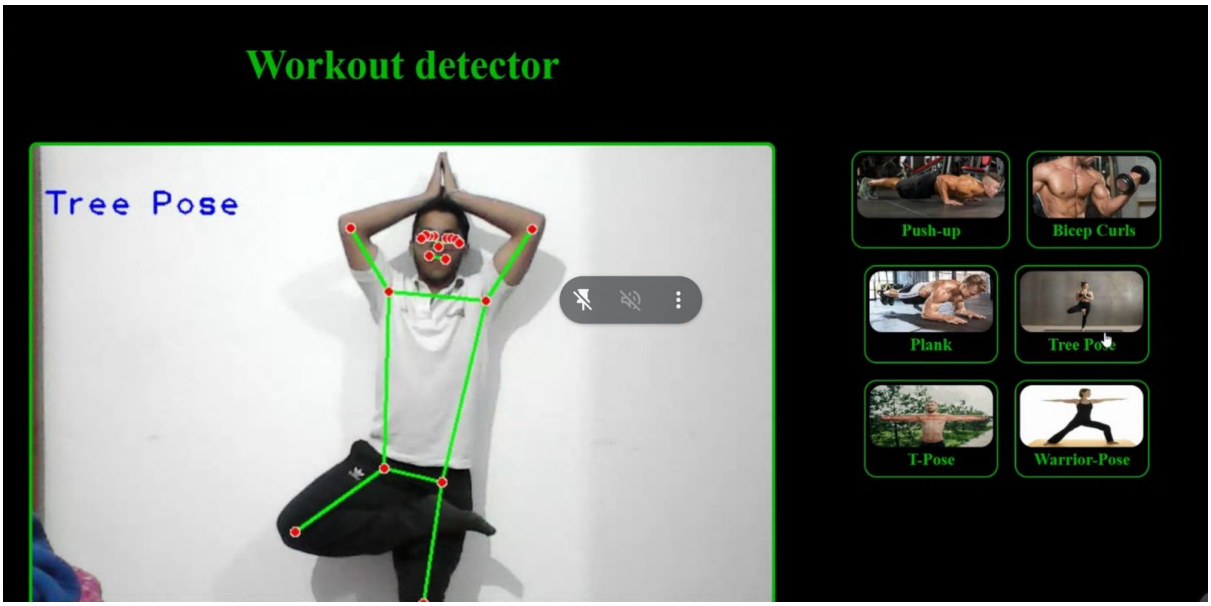

Fig 7.6- Tree Pose

6.WARRIOR-POSE:-

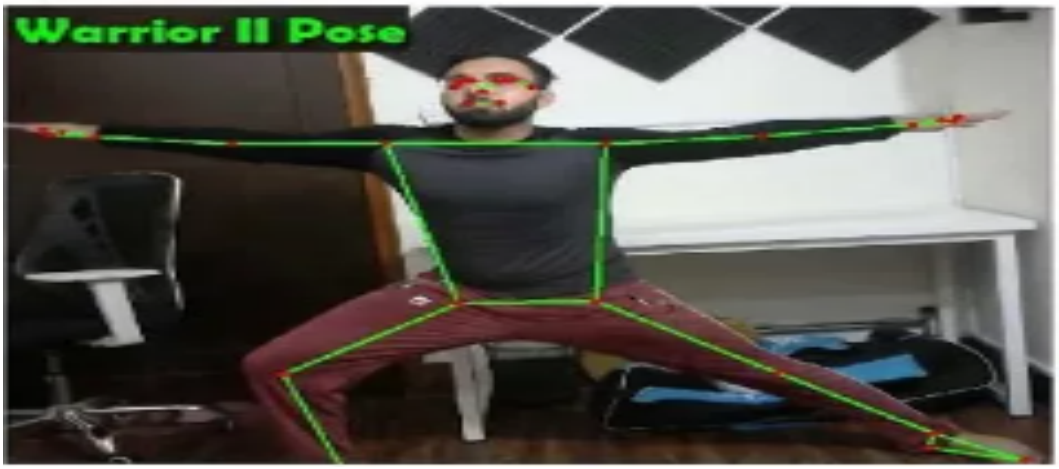

Fig 7.6- Warrior Pose

7. Plank Pose:-

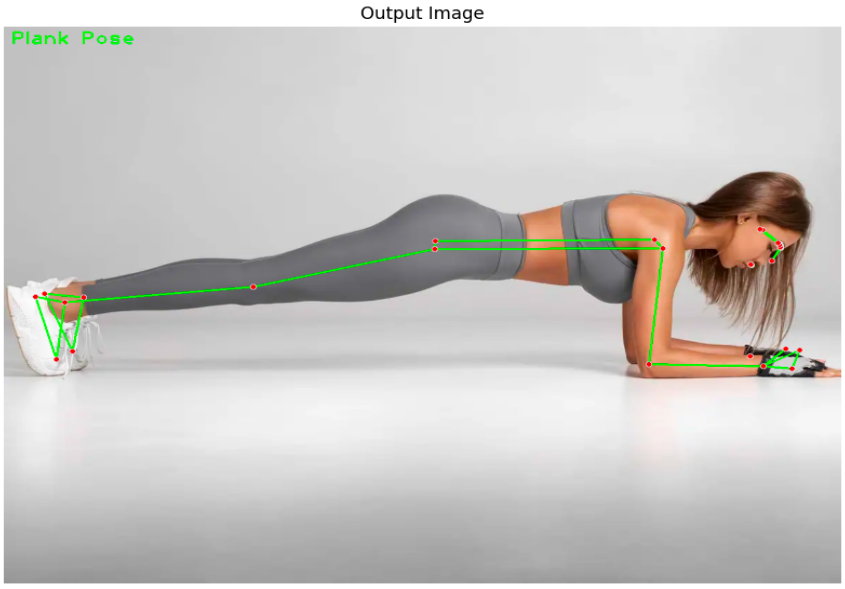

Fig 7.7- Warrior Pose

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