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Virtual Workout Pose Estimation Web Application – AI-Powered Workout Assistant System

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Abstract: *Our investigation involves developing a virtual fitness trainer utilizing artificial intelligence (AI) that will provide users with a customized and continuous workout regimen including real time feedback. We have utilized several technologies such as computer vision, machine learning and natural language processing to create an intelligent system that can detect the human pose in real time, track the number of repetitions performed during the training session and provide corrective advice. Using python's open cv library to capture live feed from a webcam we utilize media pipe's blaze pose tool to precisely measure the user's pose. We employed a new type of topology, which uses 33 keypoints; this has improved the quality of analyzing the movement of the body. To enable the users to easily use the system, we created a user-friendly front-end using flask, html/css/bootstrap. Users can select from a variety of exercises including, but limited to, squats, bicep curls, jumping jacks, push ups, lateral raises and pull-ups. In addition to selecting their chosen exercise each page contains instructions and demonstration videos detailing proper technique. The system takes advantage of a live feed from a webcam and analyzes it frame by frame and converts the frames to the required format so that they may be used to analyze the position and assess the accuracy of the pose analysis. Blaze Pose continuously monitors the user's movement in real time and displays a 33 key point exoskeleton via open cv, assisting users in determining how well they are performing their exercises and monitoring progress based upon repetition count. The system also provides the user with real time feedback about their exercise form and suggests corrections to improve performance while reducing risk of injury. The Virtual Fitness Trainer fills the void created by fitness applications that currently cannot provide the ability to independently perform accurate at-home workouts due to lack of access to gyms or personal trainers. The Virtual Fitness Trainer demonstrates one possible method of utilizing AI technology for fitness. Future enhancements to gesture recognition capabilities, dynamic work-out planning capabilities and wearable biometric devices integration capabilities could further enhance the utilization of AI technology within fitness and make the Virtual Fitness Trainer an essential component for all individuals working toward health and wellness goals.*

Keywords: Fitness Assistant, Artificial Intelligence, ML, LLM, Web Application.

I. INTRODUCTION

This paper presents a Virtual Fitness Trainer based on artificial intelligence that provides personalized workout guidance along with real-time feedback in a home environment. User's will also have access to their progress as they complete each day's workout. [1] The application will allow them to view previous work out history as well as current progress toward reaching their goal. A feature called "Workout Journal" has been added to the app that allows users to track their physical changes over time. Users will be able to view their weight loss or gain and take note of how much strength they have gained. [2]

Additionally, the user will have an option to share the pictures and videos of themselves from the journal section to social media (Facebook) if desired. The social sharing aspect could help encourage other people to use the app as well.

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[3] Overall, the app was created to be very easy to use and give users all the tools they need to reach their fitness goals. It takes away some of the stress associated with trying to get in shape, and gives you a clear path forward. [4]
Finally, the application will have a built-in customer service portal that will enable customers to contact us directly via email or phone number. If a customer ever experiences any technical difficulties or issues, we will do everything possible to assist them quickly and efficiently. We plan on continually updating and improving the application to make sure it meets all of our customer's needs.
We believe our application will become one of the leading fitness apps on the market because it combines innovative technology with a supportive community that encourages users to stay motivated.[5]

II. LITERATURE REVIEW

a variety of researchers have developed methods to identify certain actions of humans through the application of machine learning algorithms and vision-based technologies. IEEE has published articles about real time activity recognition systems that utilize cameras to capture human motion and classify various physical activities accurately [2]
the efficiency of systems utilizing pose estimation to recognize people's positions or movements has increased greatly. BlazePose, introduced by Google AI is an example of this where it uses camera images to detect a person's position in real time on lower powered computers [3]. the ability to detect those landmarks we can then use them to determine a person's posture and how they move when performing exercises.
image processing libraries like OpenCV are commonly used in order to process video data and extract information from each frame [4]. Articles that have appeared in Springer and Elsevier detail the methodologies for calculating joint angles and determining proper posture based upon landmark coordinates, which will allow us to differentiate between correct and incorrect execution of a workout [5][6].
ACM and MDPI authors have recently submitted papers detailing how posture correction using computer vision may be integrated into automated fitness tracking systems [7][8]. The papers show that if users receive instant feedback while working out, their performance and level of engagement may increase dramatically. Building off of these ideas the proposed system utilizes pose estimation.
real time processing along with user friendly interfaces was another topic of many of the recent works studied. Researchers were able to show that by combining pose estimation models with web-based interfaces, users could utilize applications within browser windows, eliminating the need for special software installations. The study also detailed attempts to improve the overall performance of the systems, enabling fast operation (low latency) and high accuracy on everyday hardware. The results will enable better usability and make the solution more viable for daily usage. As such the proposed system incorporates a light weight and scalable architecture in order to provide effective real time feedback in a home environment [2][6][7].

III. PROBLEM STATEMENT

Open_cv and blazepose technologies are used to capture and analyze user body posture from live video feeds. The system then provides instant guidance on movement patterns to help users correct their form in order to improve exercise accuracy, safety and overall fitness performance.
This use of an automated system will reduce risk of physical injury by providing instant adjustments and allow users to receive immediate feedback on how they are performing each workout.
The advantage of this type of system is that it can be used for any style of workout where proper technique is crucial.

IV. OBJECTIVES

The objectives of this research are:
1. To develop a real-time virtual workout assistant for monitoring exercises.
2. To detect human body posture using BlazePose.
3. To process and analyze video input using OpenCV.

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4. To evaluate exercise accuracy by calculating joint angles and movements.
5. To provide real-time feedback and count repetitions for improved workout performance.

V. SYSTEM ARCHITECTURE

The system follows a modular and layered architecture designed for real-time workout analysis. It consists of a frontend interface, backend processing,

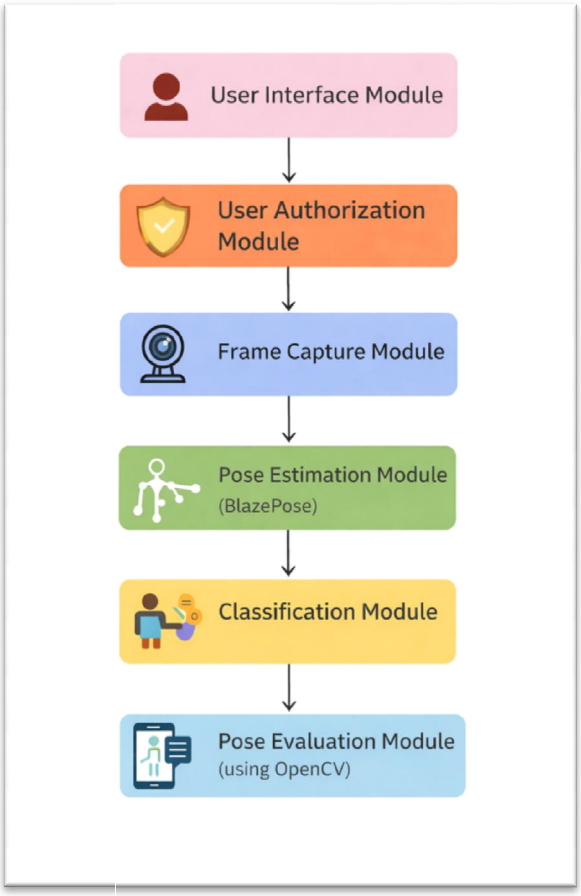

Fig. 1. System Architecture

The system follows a layered architecture consisting of:

- Frontend: HTML, CSS, JavaScript
- Backend: Node.js
- AI Module: OpenCV, BlazePose
- Database: Firebase
- External Service: Integrates browser APIs

Workflow:

Webcam Input → Frame Processing (OpenCV) → Pose Detection (BlazePose) → Feature Extraction → Exercise Detection → Rep Counting → Feedback Display → Data Storage (Firebase)

This architecture ensures modularity, scalability, and efficient data processing.

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VI. PROPOSED SYSTEM

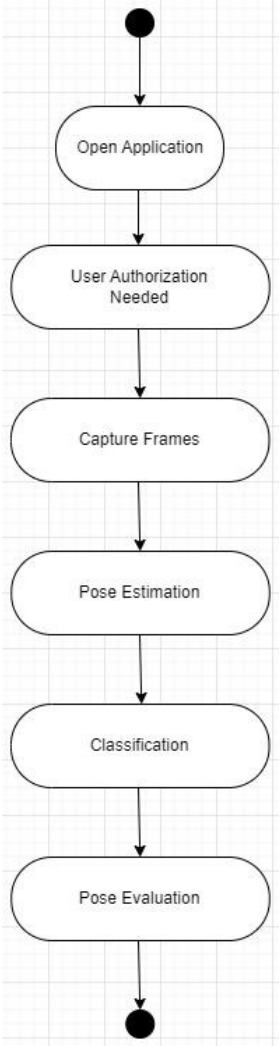

Fig. 2. Proposed System

The system consists of the following modules:

A. User Interface Module

Allows users to interact with the system and view real-time feedback.

B. User Authorization Module

Verifies user access before starting the application.

C. Frame Capture Module

Captures live video frames from the webcam.

D. Pose Estimation Module

Uses BlazePose to detect body landmarks.

Automates scholarship application and approval processes.

E. Classification Module

Identifies the exercise using extracted features and predefined rules.

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F. Pose Evaluation Module (Key Component)

Evaluates the correctness of the user's posture using OpenCV and pose data.

The module performs:

- Joint angle calculation
- Movement tracking
- Posture comparison

Outputs include:

- Correct/Incorrect posture detection
- Repetition count
- Real-time feedback
- Performance insights

VII. METHODOLOGY

System Overview: Our proposed system can be considered a real time workout assistant. It will capture the users video feed, analyze the video feed in real time, and provide feedback to the user in terms of their postural and movement patterns while they are performing an exercise [1]. Our system was also developed to create a seamless experience for both the user and the trainer/analyst by providing accurate and timely results throughout the length of the users workout session.

Data Capture: Video data is collected from a standard webcam, which collects all video feeds and breaks them down into frames. Each frame is then analyzed one at a time so that we may conduct our real time analysis [2].

Body Position Estimation (pose): BlazePose is used to estimate human body position. The software uses image processing to detect key points or body landmarks and generate a skeletonized version of the subject. This generated skeleton allows us to continue analyzing the posture and motion of the subject [3].

Pre-Processing Image Data: Using OpenCV, each frame is pre-processed before processing. Techniques include resizing images, changing color spaces, and removing background noise. These actions were taken to increase the accuracy of detecting the pose [4].

Extract Features: The system calculates the angles between joints and the location of other joints relative to each joint. The locations of these joints are determined based upon the coordinates of the landmark [5].

Recognize Exercise: Rules are created to recognize an exercise. Using rule-based classifications, joint angle values are compared to predetermined threshold values to identify what exercise is being executed by the subject [6].

Count Repetitions: The system tracks when a transition occurs between two distinct movement states; i.e., upward and downward phases. The system has been trained to count correct repetitions during every phase of an exercise cycle [7].

Evaluate Posture: Once the posture has been recognized, it is compared to known reference postures. If there is a deviation in posture from the known reference postures, recommendations are made to improve posture during the exercise [8].

Provide Feedback: Visual and text-based feedback is provided to the user in real time. Visual cues are given to indicate if posture needs correction. Textual feedback is provided to instruct the user how to better execute the desired posture [1].

Store Data: Performance data related to user performance; i.e., repetition counts and accuracy of posture is recorded in Firebase to track user's progress and support future analyses [2].

VIII. RESULTS AND DISCUSSION

the virtual workout assistant was implemented and tested in real time with an ordinary webcam. Our version of the system continually took live video feed from the webcam and quickly ran the video through the blazepose model (using open cv) so that it could identify key points on the human body. these key points are then used to track a user's posture throughout each exercise [3] [4].

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our system worked well at identifying features that are considered relevant when evaluating movement such as joints and how the body is aligned. the identified feature is then analyzed for movement pattern and the exercise type is determined by predetermined rules/ thresholds [5] [6]. The system performed effectively when determining whether or not a user's posture was correct. this indicates the potential of the system being a viable tool to assist users with their workouts [5] [6].

for tracking the number of times a user performs a given task, the system tracks the transitions from one phase of a movement to another (ie; upper position to lower). the system is capable of tracking the number of repetitions for tasks like squats and arm movements with little to no delay. because the system processes data in real time, it provides a seamless experience that does not appear to be delayed or slow [6] [7].

Feedback aspect of the system contributed greatly to improving user performance. if the system detects a user is performing a task incorrectly, it immediately provides both a visual and textual display of feedback to allow the user to immediately make adjustments [7]. In addition to typical exercise activities, we have also created a custom machine learning model to perform physiotherapy for low back pain management. this model was trained to recognize and assess 7 common rehabilitative exercises that are typically prescribed for lower back pain relief.

during testing of the system however, there were some issues that impacted its overall performance. specifically, poor lighting, limited viewing area of the body (i.e. view blocked), and improper positioning of the camera negatively impacted the system's ability to detect and evaluate landmark points and posture [2] [8].

IX. ADVANTAGES

The Virtual Workout Assistant offers several advantages in enhancing the accessibility and performance of exercising. For example, this project was designed as a virtual personal trainer where users can exercise alone at their own homes without direct supervision or involvement by an experienced fitness coach.

This allows the user to receive instant, continuous feedback on his/her postures and movements (via cameras) during every step of each exercise. As long as the user has a common device (smart phone, tablet, etc.) with a working camera installed, they are able to use this system easily and inexpensively. Due to its simplicity and minimal equipment needs, it will be accessible to most people, whether novice exercisers or those preferring home-based exercise routines.

X. LIMITATIONS

Even though the proposed application showed high-performance capabilities, there are some limitations that occurred when it was implemented and tested. There are several reasons why these limitations exist; one of which is how well the video can be analyzed frame-by-frame. The amount of time it takes to analyze each frame (or a fraction thereof) can create a small delay in the time between frames as well as possibly affect low-power devices' ability to compute quickly enough.

A second limitation exists due to the fact that the number of different types of exercises that can currently be recognized is extremely limited. These include squats, curls, jumping jacks, push-ups, lateral raises, and pull-ups. As such, this means the new application would likely have very limited usage for individuals who use a wider variety of workouts.

Finally, another limitation exists based on environmental conditions. In order for the system to accurately determine the pose of the user through computer vision, both the light levels in the area and an unobstructed view of the entire user within the camera field need to be present.

XI. FUTURE SCOPE

Based on the paper, future work would likely include:

- Expanding exercise library beyond current supported exercises
- Improving real-time feedback accuracy and response times
- Enhancing pose estimation robustness across diverse user body types and camera angles

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- Integrating additional metrics (e.g., rep counting, calorie burn estimation)
- Deploying on mobile/edge devices for broader accessibility
- Incorporating user personalization and adaptive difficulty level centralized platform for large-scale social impact.

XII. CONCLUSION

This Virtual Workout Assistant exemplifies how you may practically apply the use of computer vision and machine learning into your daily life while working out. With our implementation we were able to provide the most accurate posture detection using BlazePose and movement analysis utilizing OpenCV and also provide immediate postural correction to the user in relation to their workout or exercise [3] [4]. This proposed virtual assistant has been shown to help address some of the issues found when performing an un-supervised workout at home such as poor posture which could result in injury [5] [7].

We have demonstrated that this developed solution was both user friendly and cost effective because all that is required is a normal device with a camera; therefore providing access to a wider variety of individuals than would be possible if there were specialized equipment requirements [2]. However, the two main items which will impact system performance are lighting conditions and camera placement. Overall, however, these results show that this model is very reliable for use in real time [8].

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