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Real-Time Exercise Tracking System

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Abstract

The increase in popularity of fitness and at-home fitness has illuminated a major deficiency with traditional fitness tracking; the absence of immediate motion analysis and corrective feedback. Many conventional methods of instruction, as well as wearables, lack the system feedback of prompting users for proper movements, which can lead to many real workout injuries. The proposed system is the "Real-Time Exercise Tracking System". The proposed project is an intelligent method of intervention that uses computer vision and deep learning to provide a solution to the problem of lacking immediate feedback. The objective of the system is to accurately assess the form a user is exercising in, and properly provide the user with effective feedback on their form in real-time. The system utilizes a combination of MediaPipe for estimating accurate user pose, and a machine learning model to assesses the required movements of the user. The application provides the user with real-time voice and visual feedback on motion awareness. The application will assess the user's exercise awareness in terms of AI-based form correction, real-time performance analytics, propose new workouts based on previous fitness activities, and mitigate risk of injuries with alerts. The project will contribute to filling the gap between unmonitored home activity and professional fitness education, thus creating a safer, more effective, and happy fitness experience for users.

Keywords – Real-Time Tracking, Pose Estimation, Computer Vision, MediaPipe, Fitness Technology, Deep Learning, Form Correction

I. INTRODUCTION

Globally, the perception of health and fitness has rapidly evolved, ever increasing numbers of people are taking up home-based workout routines. The pandemic has accelerated this trend and demand for convenience and accessibility. While there are numerous fitness apps and wearable trackers on the market today, they tend to focus on tracking performance measures such as steps taken, heart rate, and calories burned, and tend to ignore the qualitative element of exercise, which is proper form and posture.

In fact, this absence of motion analysis has a grave consequence. Exercising with incorrect postures will not only limit the effectiveness of your exercise routine but will also significantly increase the risk of injury. Exercise without the guidance of a training professional will result in chronic pain and ongoing musculoskeletal problems. There is certainly a gap for a product that acts intelligentially like a personal trainer at home and can offer instant corrective feedback.

To fill this gap, we have developed the Real-Time Exercise Tracking System. This project consists of a web-based application that uses a device's camera and computer vision (using Machine Learning) to provide users with direct feedback on their movements. The system analyzes the user's posture and compares it to correct models of exercise. Then, the system provides information (both voice information and visual information) to prevent the user from unsafe movements and overexerting themselves. This project brings the accessibility of home exercise and precision with AI-Personal Training together to make fitness safer and easier to do successfully at home for everyone.

II. LITERATURE SURVEY

The area of AI-enabled fitness has grown in importance and there are many studies focused on technology use to improve exercise effectiveness. One more common thread in the literature is the need to provide feedback in real time about exercise form to avoid injury, which is often led to poor form when training with older methods without immediate feedback. This survey will uncover the main technologies and approaches being used in modern exercise tracking systems.

A basic requirement of a real-time exercise tracking system is human pose estimation, or determining human joint locations within images and videos. For this task, there are several robust frameworks that are referenced repetitively. The MediaPipe framework, is often used to detect 33 body landmarks in a 3D space, and then calculate features such as joint angles and distances. The OpenPose library is a second popular framework for detecting 18 key body points and joint locations. There are many other models that are also advanced, like MoveNet, that are used for detecting exercises. A few studies utilize object detection models, like YOLOv5, to find important body points and analyze movement in real time to help adaptive fitness programs.

Once the pose data has been extracted, various machine learning (ML) and deep learning (DL) models can then be used to classify exercises and assess form. Deep learning approaches exploit deep convolutional neural networks (CNNs) to automatically extract spatial features from visual data. To capture the temporality of a normative exercise, other models augment CNNs with the transformer architecture to analyse time-varying data. Many studies compared using hybrid models (e.g., using a CNN as a feature extractor and a Random Forest (RF) classifier) to classify exercise routines, achieving high accuracy label in-class gym exercises. Other studies made use of traditional ML algorithms like decision trees or gradient boosting to classify workouts given extracted features.

From a system architecture perspective, the creation of such applications typically employs a few flexible programming languages and frameworks. In regard to machine learning, Python is one of the main languages because it has many libraries and frameworks, such as Tensorflow, that focus on large-scale machine learning and model training. Node.js was used for the server-side process and the Express.js framework was utilized for building local server-side logic and API for the application. ReactJS was used on the client-side to furnish dynamic and interactive user interfaces for single-page applications. For data, NoSQL (e.g. MongoDB) was used for its flexibility to structure data in document form while still being able to manage user profile information and workout data intently.

III. METHODOLOGY

The Real-Time Exercise Tracking System was developed in a full-stack architecture, to include a responsive front-end, a functional back-end, and a machine learning model to ensure a seamless experience for the user.

- **Technology Stack:**

• Frontend: The front-end uses React.js (for UI) along with Bootstrap and Material UI.

• Backend: The backend leverages various languages and modules, with Node.js, Express.js, Python (API & server-side logic).

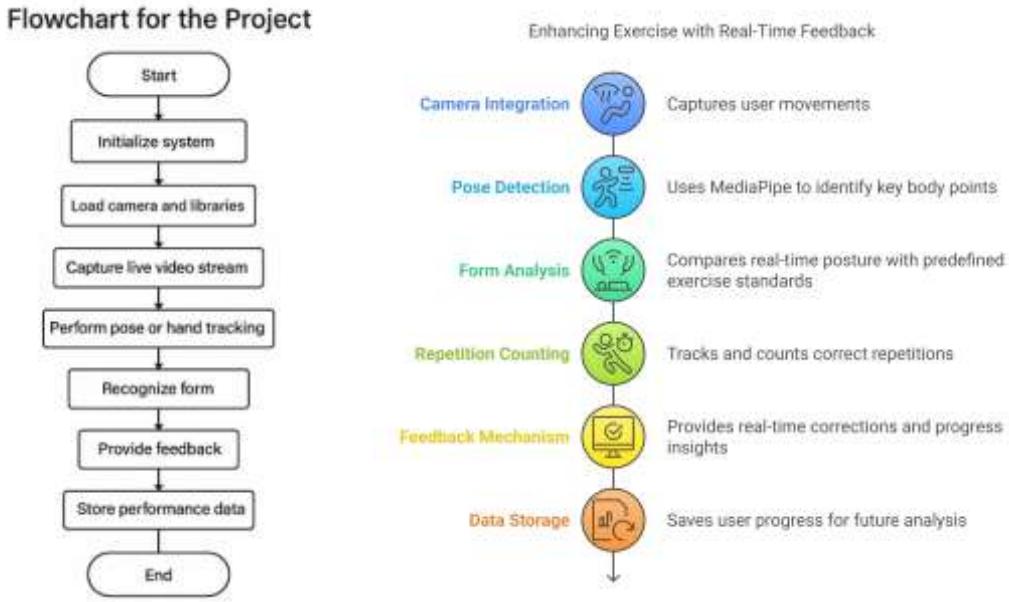
• Machine Learning: The application uses MediaPipe (for pose detection) and TensorFlow/PyTorch for model training.

• Database: User information, exercise data, and user workout plans are all stored in either an SQLite or MongoDB.

• Camera Integration: Real video input from the user's device is recorded and utilized using OpenCV, in a real-time manner.

• Deployment: The application will be deployed in a cloud service like Heroku or Render.

- **System Workflow:**



1. Video Capture: The user initiates a workout session, and the system interacts with their camera feed with OpenCV to capture a live streaming video of their practice.

2. Pose Estimation: Each frame of the video is passed on to the MediaPipe framework, which detects and retrieves the coordinates of unique body landmarks.

3. Movement Analysis: This window of landmark coordinates is passed on to a trained TensorFlow/PyTorch model. The model, or algorithm, calculates joint angles, assesses posture, tracks repetitions, and compares whether the user's form matches a predefined model of correct exercise posture.

4. Feedback Generation: The system generates real-time, actionable feedback based on the responsiveness of the model. When incorrect posture is detected, an audible voice notification, with a visual cue, was provided to the user.

5. Data Capture and Visualization: Performance metrics, such as the number of repetitions, form accuracy, speed, level of stability, etc., are captured in the database and visualized within the user's React.js dashboard, allowing the user to observe how they progress over time.

IV. EXPECTED RESULTS

It is anticipated that the Real-Time Exercise Tracking System that has been built will provide a robust, user-centric environment to improve the safety and performance of home exercise.

• High-Accuracy Pose Detection: The system will present high-accuracy detection to determine user's body posture and movement in real-time, which is made possible by the landmark detection capabilities from MediaPipe.

• Real-Time Corrective Feedback: A major output will be the ability to provide real-time, intuitive feedback. The system will deliver form corrections via voice and visual alerts, much like a virtual personal trainer.

• Complete Performance Analytics: Users will have a dashboard which will provide real-time analytics including speed, stability, and endurance metrics.

• Reduction of Injuries: The system will be able to alert users of dangerous motion samples, and provide alerting if they get too fatigued or exert too much energy which will minimize workout injuries that can occur in an unsupervised environment.

• Increased Engagement: Inteventions like gamification, leaderboards, and achievement badges provide users with motivation for greater engagement.

V. FUTURE WORKS

The core system will continue to provide instant feedback, while upgrades will move towards a more bespoke, intelligent fitness ecosystem.

• Adaptive Learning System: This will be developed as adaptive learning program which will dynamically update the intensity of workouts, curate tailor made exercise operations based the users fitness goals, targets, and previous performance.

• Exercise library: the exercise library will grow immensely and process a great number of other exercises (for instance, we will be adding yoga, pilates, and then all variations of strength training exercises).

• Multi-user and Trainer experience: this will be further developed to enable multi-user sessions, allowing for real time competition and collaboration with friends or trainers.

• Wearable device integration: this will sync with other devices, smart-watches, and fitness bands, while including other physical metrics to performance analysis training sessions.

• Cloud analytics: we will implement a cloud based analytics platform which will automate reporting data based insights and long-term fitness progress reporting.

VI. PROJECT SCREENSHOTS

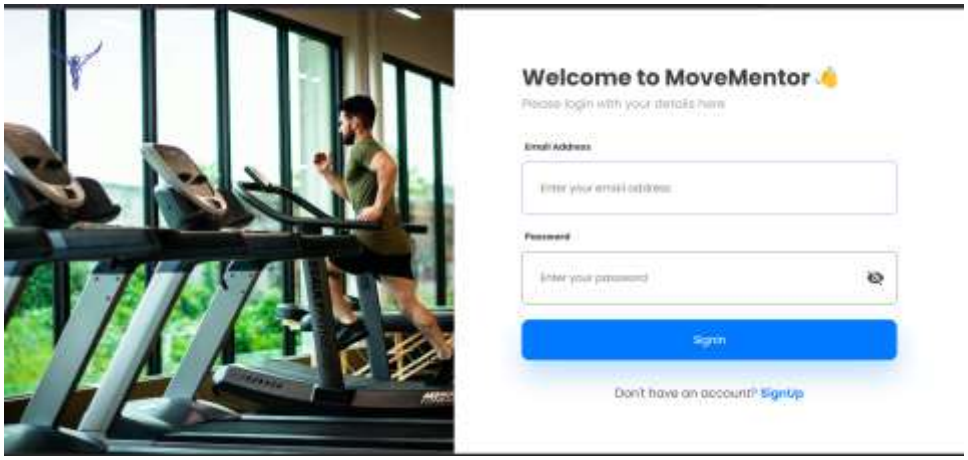


Image 1: Login Page

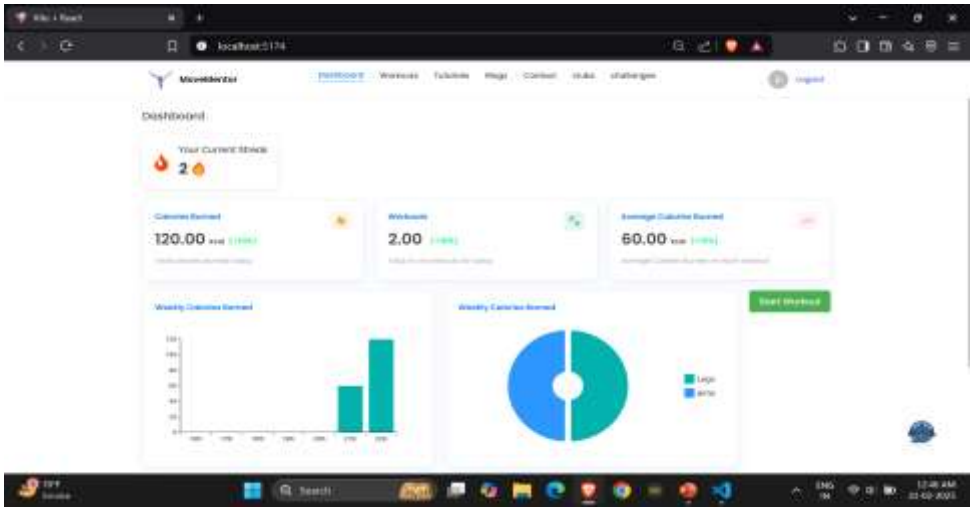


Image 2: User Home Page

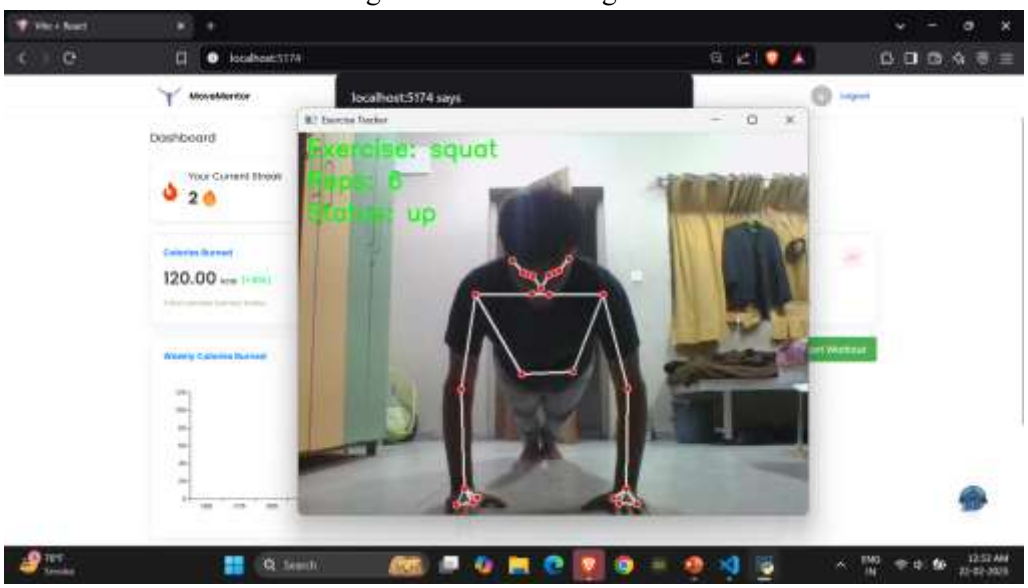


Image 3: Exercise Page

VII. CONCLUSION

The Real-Time Exercise Tracking System effectively meets an urgent situation for users seeking safe and effective support within the rapidly growing field of home fitness. By successfully implementing computer vision and machine learning techniques, it provides users a solution that is simple to obtain that emulates the role and feedback of a personal trainer. Analyzing the movements that the user makes and providing immediate, corrective feedback on exercise form can help mitigate the likelihood of injury and increase exercise efficiency. The modern technology stack maximizes the power of the platform while providing scalable and responsive features. In the end, the project represents a strong platform for future intelligent fitness processes that value convenience, safety and well-being of users so that they can continue to work towards their health-related goals.

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