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Artificial Intelligence-based Personal Fitness Trainer

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Abstract: *Human Activity Recognition has emerged as an active research area in recent years. With the advancement in mobile and wearable devices, various sensors are ubiquitous and widely available gathering data from a broad spectrum of peoples" daily life activities. Research studies thoroughly assessed lifestyle activities and are increasingly concentrated on a variety of sports exercises. A fitness trainer can motivate and teach users to do fitness activities. However, using a human fitness trainer may involve high costs and is not suitable for certain individuals. Also due to the number of norms imposed due to the outbreak of Covid, people find themselves unable to carry out the exercise at their convenience due to reasons such as lack of time, lack of motivation, and importantly lack of experts.*

Keywords: Human Activity Recognition, Sport Activities, Mediapipe, OpenCV

I. INTRODUCTION

Going to the gym is one of the common goals of New Year"s Resolutions. As a matter of fact, the highest rate of gym subscriptions is in January, right after New Year"s. In January 2012, 80% of those who joined a gym quit within 5 months. But laziness isn"t the only reason gym members quit. Approximately 46% of former gym members reported that expense was the number one reason why they stopped using their membership [1]. Therefore, it is apparent that cost is a crucial factor in deciding whether or not to subscribe to the gym, even without the cost of hiring a personal trainer [4]. Professional Gyms/health clubs may offer personal trainers as a supplementary service. Even in this case, however, users are not constantly guided and supervised during their exercises in a way, which is beneficial. Personal trainers are still a large cost factor and thus, there can not normally be assigned a personal trainer per athlete over their entire training session [5].Our project is a digital AI Personal Trainer that can supervise users in their training and has great potential to support both professional and amateur users. A system integrated into sports equipment that can guide user exercising through their training not only helps to motivate people but also mainly supervise athletes performing sports activities, and undergoing fitness training, which increases the safety and efficiency of their training. The process of providing a personalized trainer for every user requires time and money.

II. LITERATURE REVIEW

A. SmartCoach Personal Gym Trainer: An Adaptive Modified Backpropagation Approach [4] This paper proposes the use of an enhanced back propagation algorithm for developing a device that functions as a personal exercise trainer. It offers a full workout program, monitors the user's workout, counts down the reps, and alerts the user when the move is performed incorrectly. Due to the real-time nature of the workout, an efficient algorithm must be used. An improved algorithm, known as the Adaptive Modified Backpropagation (AMBP) algorithm is used.

B. AI Fitness Trainer: In our project, we introduce AI Trainer, an application that detects the user's exercise pose and provides personalized, detailed recommendations on how the user can improve their form. Pose Trainer uses the state of the art in pose estimation module known as "BlazePose" tool from "MediaPipe" to detect a user's pose, then evaluates the pose of an exercise to provide useful feedback. We record a dataset of over 1000

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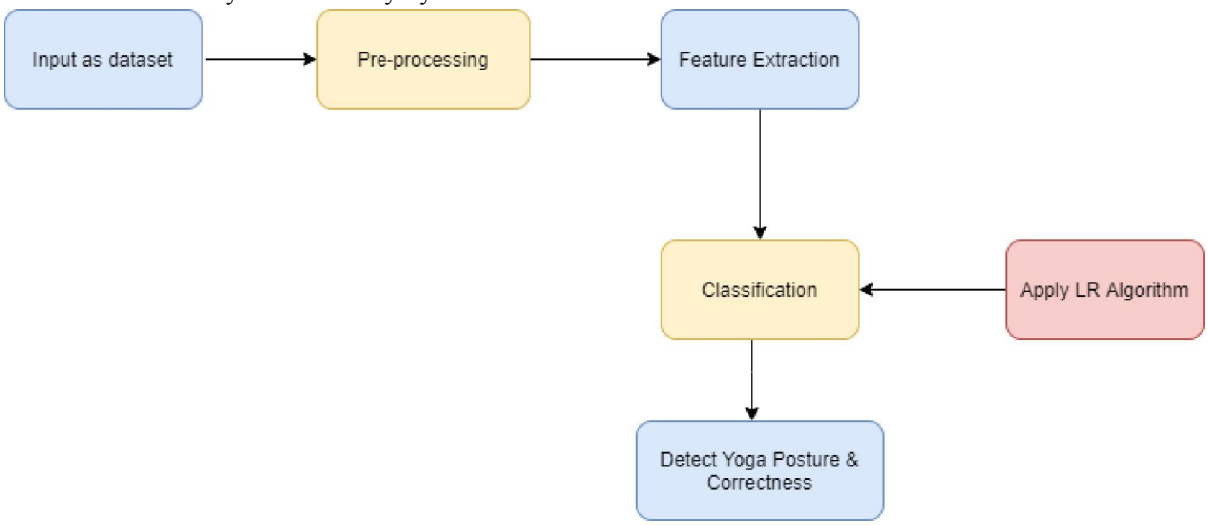
keypoints coordinate of parts of body in correct and incorrect form, based on personal training guidelines, we build a machine learning algorithm for evaluation.

III. METHODOLOGY

User Classes and characteristics After logging into our system, the user can access the GUI page. Yoga positions can be detected correctly or incorrectly by the user



3.1 Human Pose Estimation

Human pose estimation tasks are to detect human skeletons' points to represent human real poses. Selecting a suitable model is essential for our application as it needs to handle cases under both simple and complex environments in realtime. OpenPose is a classical and excellent model that uses the part affinity fields and convolutional neural networks(CNN) to localize the human joints. [5] introduces the boundary box to reduce the redundant information during the detection to improve accuracy. Although OpenPose can handle its tasks in real-time accurately, the raw version requires GPU to accelerate convolutions which causes large memory usage. [5] is limited by the performance of its boundary detection algorithm so that it is not stable in some cases. [6] develops a lightweight OpenPose and can run on the CPU but the performance is still challenged. Currently, we select raw OpenPose as our human estimation model and we left the exploration of more advanced models in future works.

3.2 Score Calculation Angle Calculation

The angles α on each key point of the whole detected body is calculated by the equations below in order to be used for score computation in the subsequent steps.

$$\alpha = |a1 - a2|, \text{ if } a1 \cdot a2 \geq 0 \; |a1| + |a2|,$$

otherwise where we assume there are two vectors $-\!\!\rightarrow x1 = (x1-x0, y1-y0)$ and $-\!\!\rightarrow x2 = (x2 - x0, y2 - y0)$ to calculate a1, a2 as, a1 = arctan(y1 − y0 x1 − x0), a2 = arctan(y2 − y0 x2 − x0)

3.3 Score Computation

By given the angle from user and instructor at keypointi, the score can be computed as:

$$\Delta i\% = \alpha user,i - \alpha instructor,i \; \alpha instructor, i \cdot \alpha instructor,i \; \pi \cdot 100\%$$

where, α instructor, i represents the angle of keypoint i for the instructor and α user, i represents the angle of keypoint i for the user. These percentage differences are scaled by the angles of the corresponding keypoint s to improve the robustness of the results, especially when the angle of a particular keypoint is relatively small. In addition, the percentage differences could be either positive or negative which is used to indicate the direction that the user's body parts should move towards. The score for a particular keypoint i could be computed by:

$$scorei = (1 - |\Delta i\%|) \cdot 100\%$$

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3.4 Data Pre-Processing

We divide the training process into 4 main steps for all kind of poses (i) Start Step, letting user standstill for preparation,(ii) Pose Step: describing the pose, (iii) Breath Step: asking the user to inhale and exhale, (iv) End Step: indicating that the training process finishes. All steps follow their pre-designed scenarios to give vocal instructions. During step (iii), the mobile takes the pose photo and sends it to the host backend to complete the keypoints detection. The backend then calculates scores(see II-B), generates a detailed feedback message based on obtained evaluation scores as well as the position information of that key-point and sends them back to the mobile. All the messages are finally spoken out via the raw android text-to-speech module. To facilitate the addition of new scripts flexibly, we store these message words in a database.

IV. CONCLUSION

In this project, performed training and tacking of users performing fitness exercises in modern gyms using Mediapipe Pose ML pipeline and OpenCV. The results showed that our system can monitor and accompany users through different exercises like bicep curls, triceps rope pulldown, and inclined chest press efficiently. The system accurately tracks the user all the time and measures the respective body angles precisely. The system also avoids counting inaccurately performed reps/exercises. Our project monitors and update user about information regarding exercises being performed such as reps done, stage of rep as well as the percentage of activity done. AI-based Personal Gym Trainer does not necessitate the cost and overcomes the limitations of a Human Trainer. Therefore this system holds the potential to successfully replace the same.

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