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trAIner - An AI Fitness Coach Solution

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***Abstract*—Physical activity and exercise can have immediate and long-term health benefits. But when it comes to working out, form is the most important thing. Poor form places undue emphasis on muscles, tendons, and ligaments, leading to strains and sprains. Good form reduces overcompensation and the likelihood of injury. This is one of the many reasons why people work under the guidance of a trainer. Whether one wants to develop an individualised program, or simply feel that they would benefit from the additional accountability, a personal trainer can be a great resource. Online coaching and virtual training have emerged as a staple in the fitness industry. Owing to technological advancements, with a suitable application, one can get constant reminders and a much-needed drive to focus more on fitness and nutrition. Over the years, AI has spread its roots in almost every functional area of business.Pose estimation is among the most popular solutions that AI has to offer; it is used to determine the position and orientation of the human body given an image containing a person. Our goal is to implement an automated fitness coach solution which performs all the tasks of a physical personal trainer. The app obtains users' motion data by the use of a webcam, and then applies human pose estimation assisted with repetition counting and form evaluation via voice based real time feedback.**

***Index Terms*—Artificial Intelligence, fitness, form evaluation, pose estimation, voice feedback.**

I. Introduction

Physical activity and exercise can improve one's health both now and in the future. Adults should aim for at least 150 minutes of physical activity over a week through a variety of activities. Aerobic, muscle-strengthening, bone-staining, and stretching are examples of exercises that support the body in different ways. Adults that are physically active have a lower risk of depression and cognitive loss as they age. Physical exercise reduces the risk of developing a variety of diseases, including CHD, diabetes, and cancer.

A personal trainer can help you to set achievable goals and keep you on track to achieve them. However, there are a few downsides to having a personal trainer, such as over-reliance on trainers or selecting a trainer who lacks experience or qualifications. Availing the benefits of a PT is also expensive. *trAIner* tries to eliminate all the barriers to exercise, such as cost and access. It comes with a workout recommendation and a routine generation system.

II. Problem Description

trAIner aims to incorporate Artificial Intelligence in order to correctly recommend a particular set of exercises to an individual and also monitor them. Initially, the registered user will be provided a questionnaire which will help us acquire the required information about the person's medical history. Depending on the user's medical history, including injuries and medical conditions, the workouts that are not advisable will be filtered out. A routine is generated based on the above factors and the number of hours and days per week the individual is willing to dedicate. The workouts are monitored using the pose detection model, which keeps an eye on the form of a particular workout as well as a count of the number of repetitions that are being performed. The exercise feedback is given instantly through a voice-based system, making sure the individual knows whether he is performing the work properly.

III. Related Work

A personal trainer is essential, not only for resistance exercise programming, but also for client education. A study [3] was conducted on 46 females who have had consistent resistance training experience. In this study, they were divided in two groups, one worked under the guidance of a personal trainer($n = 19$) and the other, without any influence of a personal trainer($n = 27$). The directly supervised, heavy-resistance training in moderately trained women resulted in a greater rate of training load increase and magnitude which resulted in greater maximal strength gains compared with unsupervised training.

Chen, Steven et al. [2] implemented an end-to-end computer vision application that provides tailored feedback on fitness workout form using pose estimation, visual geometry, and

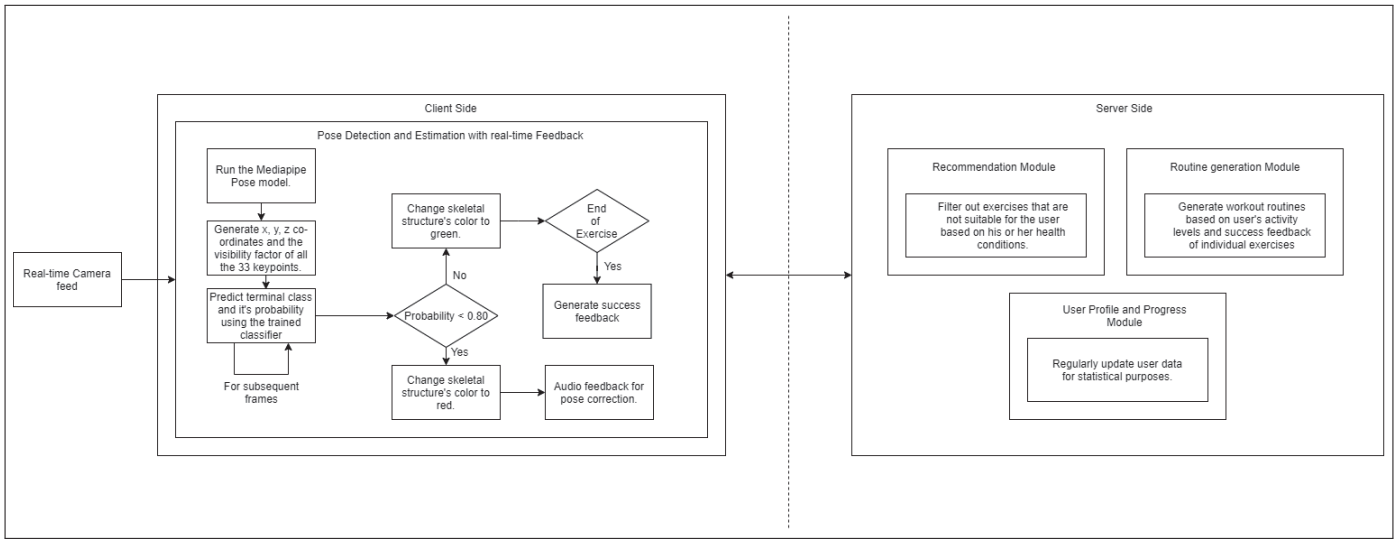

Fig. 1. System design

machine learning. In this project, they use a pre-trained model(OpenPose) to evaluate workout videos with the help of human pose keypoints. The keypoints are compared with results computed from 100 correct as well as incorrect exercises. The system also outputs verbal feedback to users. However, this implementation didn't provide any support to real-time pose estimation and feedback.

Zou J. et al. [1] presented, The intelligent fitness trainer system, which not only displays fitness development programs but also provides support for pose correction. It generates feedback reports at the end of the entire exercise process, including details of movement errors, corrective guidance and motion accuracy scores, maximum error points, best progress points, calorie consumption, and so on, to boost the users' sense of fitness accomplishment and interest in fitness. However, the user's medical history is not taken into account by this system. With *trAIner*, our goal is to not only learn from previous work, but also to improve and incorporate features that are often overlooked but are critical in any training software.

IV. Implementation Approach

The implementation of *trAIner* comprises multiple modules, both on client side and server side (see Fig. 1).

A. Workout Recommendation

Although moderate physical activity is generally safe for most people, health experts recommend consulting with your doctor before beginning an exercise programme if you have heart disease, type 1 or type 2 diabetes, hypertension, arthritis, or are undergoing cancer treatment under medical supervision [8]. As soon as the user registers on to the website, the aforesaid element will be taken into account. The exercises that are not advised for the user will be filtered out based on his or her medical complications, and a subset of workouts from *trAIner*'s extensive workout database will be assigned to him or her. The database will contain exercises belonging to each of the major six muscle groups of the human body.

B. Routine Generation

The American Heart Association [6] suggests that you receive at least 150 minutes of moderate-intensity aerobic activity or 75 minutes of strong aerobic activity each week (or a combination of both) spread out throughout the week. Keeping this in mind, the user's workout regimen will be generated based on his or her daily activity level, end objective and the number of days the user wants to dedicate. This routine will include a set of workouts as well as pertinent information. The BMI will be utilised to further narrow down the appropriate number of sets and repetitions of an exercise required before assigning it to the user, as it is a good predictor of one's health. The routine(see Fig. 2) will be generated based on the above factors and the Workout Recommendation subsystem.

C. Pose Detection and Estimation

For pose detection, classification, and counting repetitions, *trAIner* uses Mediapipe Pose. Mediapipe Pose uses BlazePose [4], a real-time body pose tracker. BlazePose generates 33 body keypoints for a single person (see Fig. 3).

To train the classifier, we create a training set of two classes, each representing a terminal state of the exercise. For a bicep curl workout, we, for example, hold 'arm up' and 'arm down' positions. We record a long enough video with different camera angles to capture both terminal classes precisely. Following that, each of the 33 landmarks in the capture frame is located and tracked. The x, y, and z coordinates, as well as the visibility of these 33 landmarks associated with the exercise state, make up our training data-set. After obtaining the training sample, we pass it to a Random Forest Classifier. The random forest algorithm is not biased, since, there are multiple trees and each tree is trained on a subset of data.

Example Routine for 3 days a Week

Monday: arms and shoulders

- **push-ups:** 3 sets of 8 reps
- **biceps curls:** 3 sets of 8 reps
- **shoulder press:** 3 sets of 10 reps
- **bench dips:** 2 sets of 12 reps
- **lateral raises:** 3 sets of 10 reps

Wednesday: legs

- **barbell back squats:** 3 sets of 8 reps
- **dumbbell lunges:** 2 sets of 10 reps
- **Romanian deadlifts:** 3 sets of 8 reps
- **step-ups:** 2 sets of 12 reps
- **calve raises:** 3 sets of 12 reps

Friday: back, chest, and abdominals

- **dumbbell bench press:** 3 sets of 8 reps
- **dumbbell fly:** 3 sets of 8-10 reps
- **bicycle crunches:** 3 sets of 20 reps
- **one-arm dumbbell rows:** 3 sets of 8 reps
- **dumbbell bent-over rows:** 3 sets of 8 reps
- **crunches:** 3 sets of 20 reps

Fig. 2. A three-day routine as an example.

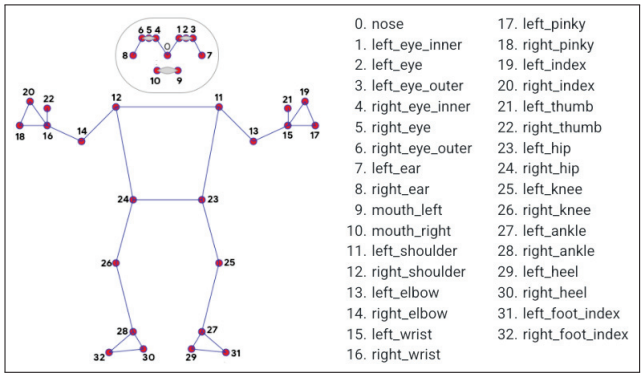

Fig. 3. Pose Landmarks (BlazePose GHUM 3D)

Only the terminal states must be classified in our approach, making it a binary classification problem. The random forest classifier finds it fairly easy to distinguish between the two states and has been chosen as the algorithm for this particular problem.

We create our own dataset by collecting a few hundred samples for each terminal state of the exercise in order to develop a virtually accurate classifier. Out of the two terminal states, the state having a higher probability is chosen during the pose prediction phase.

The computed probability(p) of a terminal state also helps us to keep count of the number of repetitions (see Fig. 4).

D. Voice-based Feedback

To get the most out of an activity, it is vital to maintain proper form. *trAIner* includes real-time voice feedback to help the user get the most out of their training. The voice-based feedback module will be triggered if any inconsistencies are discovered during the pose estimation phase.

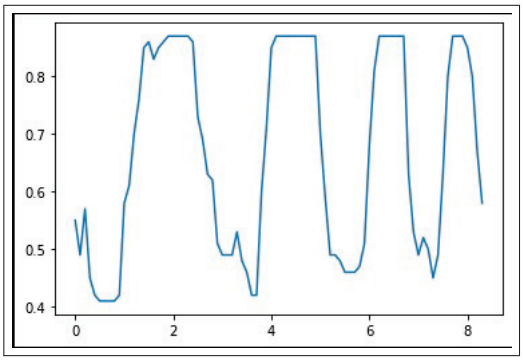

Fig. 4. One repetition is the time it takes to go from $p \approx 0.0$ to $p \approx 0.80$ probability and back to $p \approx 0.0$.

V. Results

A. Bicep Curl

Fig. 5. Movement of the arms being correctly classified during the pose estimation phase of a bicep curl exercise.

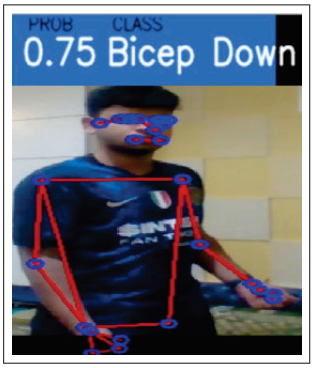

Fig. 6. An improper form detected during the pose estimation phase of a bicep curl exercise.

Bicep curls are performed by standing with a dumbbell in each hand, elbows at sides, and forearms extended in front of the body. Bending our elbows, we then bring the dumbbells all the way up to our shoulders. After a little pause, we progressively reverse the curl and repeat.

The movement of the arms can be divided into two categories in our implementation: 'Bicep Up' and 'Bicep Down'. The skeletal structure flashes green as a visual indicator whenever the classifier classifies the current pose as either 'Bicep Up' or 'Bicep Down' with a probability of more than 0.80 (see Fig. 5). The skeletal structure turns red when the probability falls below 0.80 (see Fig. 6).

B. Shoulder Press

In a shoulder press exercise, we hold a dumbbell in each hand with our feet hip width apart, bend our elbows to the side, and raise our arms to shoulder height.Dumbbells should be placed at ear height. We raise the dumbbells until our arms are nearly fully stretched vertically, then return to the starting position and repeat.

Similar to the bicep curl, the movement of the arms in a shoulder press can be divided into two classes: 'Press Up' and 'Press Down' (see Fig. 7 and Fig. 8).

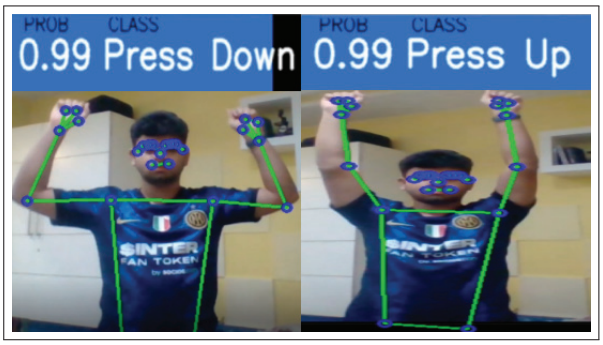

Fig. 7. Movement of the arms being correctly classified during the pose estimation phase of a shoulder press exercise.

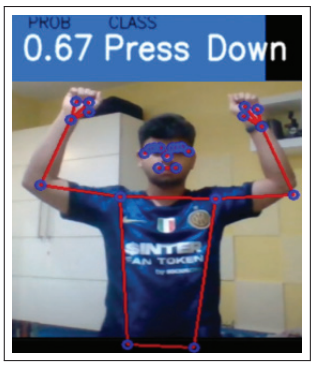

Fig. 8. An improper form detected during the pose estimation phase of a shoulder press exercise.

VI. Conclusion

trAIner is a smart AI-based personal trainer that is both portable and intelligent. The application will run in the browser, making it simple to use, and the lightweight pose estimation model will make the pose detection process faster and more efficient, leading to quicker results.

By using a fully software-based system and eliminating all of the hardware needs of conventional systems, the platform becomes more affordable and accessible to the general public.

References

[1] Zou J. et al. (2019) Intelligent Fitness Trainer System Based on Human Pose Estimation. In: Sun S., Fu M., Xu L. (eds) Signal and Information Processing, Networking and Computers. ICSINC 2018. Lecture Notes in Electrical Engineering, vol 550. Springer, Singapore.

[2] Chen, Steven and Yang, Richard. (2018). Pose Trainer: Correcting Exercise Posture using Pose Estimation.

[3] Ratamess NA, Faigenbaum AD, Hoffman JR, Kang J. Self-selected resistance training intensity in healthy women: the influence of a personal trainer. J Strength Cond Res. 2008 Jan;22(1):103-11. doi: 10.1519/JSC.0b013e31815f29cc. PMID: 18296962.

[4] Bazarevsky, Valentin and Grishchenko, Ivan and Raveendran, Karthik and Zhu, Tyler and Zhang, Fan and Grundmann, Matthias. (2020). BlazePose: On-device Real-time Body Pose tracking.

[5] Nicholas Renotte (2019) Body-Language-Decoder [Source Code] https://github.com/nicknochnack/Body-Language-Decoder.

[6] "How much physical activity do you need?", American Heart Association, Mar 16, 2021, [Online]. Available: https://www.heart.org/en/healthy-living/fitness/fitness-basics/aha-recs-for-physical-activity-infographic

[7] What Muscle Groups Are Best to Work Out Together?, healthline, Medically reviewed by Jake Tipane, CPT — Written by Daniel Yetman on May 28, 2020, [Online]. Available: https://www.healthline.com/health/exercise-fitness/muscle-groups-to-workout-together

[8] Mayo Foundation for Medical Education and Research. (2021, February 24). When to check with your doctor before exercising. Mayo Clinic. Retrieved May 25, 2021, from https://www.mayoclinic.org/healthy-lifestyle/fitness/in-depth/exercise/art-20047414.