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Exercise Pose Detection and Correction

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Abstract: *Regular physical activity can improve your muscle strength and boost your endurance; but, lifting weights requires proper technique in order to protect yourself from injury and to get the most out of your workout. Improper exercise form can make is highly inefficient and hazardous. In this report we propose a software application that detects users pose and gives personalized, detailed feedback so that user can correct his form. Our application uses OpenPose library which is the state of the art in pose estimation to detect a user's pose, then calculates the vector geometry of the pose to provide valuable feedback. We recorded around hundreds correctly and incorrectly done exercise videos to train our ML model. We use geometric heuristic algorithm for giving personalized feedback as well as Dynamic Time Warping which is a machine learning algorithm for measuring correctness of exercise. Our application can be run on any PC with GPU and windows or Linux Operating system.*

Keywords: Dynamic Time Warping, Vector Geometry, 2D Human Pose Estimation, 2D Foot Key Point Estimation, Real-time, Multiple People, Part Affinity Fields, etc.

I. INTRODUCTION

Peoples are in need of a healthy lifestyle. A healthy lifestyle consists of healthy food, healthy physical activities, weight management and stress management etc. It is feasible for people to maintain a healthy life easily by healthy physical activities. But due to the lack of free time in their daily routine, most people prefer to do exercises on their own with the use of an instruction manual or guides that could be found online. Many people work out and perform these exercises regularly but do not maintain the proper form (pose) and this could lead to a hazardous lifestyle.

Personal trainers at the gym are definitely a good option, but post COVID, most of the gyms have shut down and many people have started preferring home workout over gyms. So, the next option is remote training, where usually people interact with their personal trainer by sending recorded workout sessions. This approach lacks real-time feedback. Also, people might not be comfortable sharing their videos.

Exercises such as squats, deadlifts, and shoulder presses are beneficial to health and fitness, but they can also be very dangerous if performed incorrectly. The heavy weights involved in these workouts can cause severe injuries to the muscles or ligaments. Many people work out and perform these exercises regularly but do not maintain the proper form (pose). This could be due to a lack of formal training through classes or a personal trainer, or could also be due to muscle fatigue. Therefore, it is mandatory to have good guidance for people. A proper guidance will lead to gain many benefits from exercises and improve the health of a person.

II. PROBLEM STATEMENT

Design a software application that takes as input live video of user performing exercise and provides user with personalized feedback that gives user suggestion to improve his/her form and measures accuracy of user's form using pose estimation. It also provides user detailed instruction on how to perform certain exercise.

III. LITERATURE SURVEY

A. Pose Trainer: Correcting Exercise Posture using Pose Estimation

In this research paper, author proposes a desktop application that takes as an input video file of user performing exercise from particular perspective and gives personalized feedback on command line so that user can correct his posture. User is given choice when it comes to choosing video format and video editing software. This application is based on OpenPose library which uses state of the art pose estimation technique. It is based on two models:

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1. Machine-learning based model
2. A heuristic model based on vector geometry

Author used personal training guidelines and our own recorded videos to design geometry based heuristic model and approached Machine learning model by using dynamic time warping (DTW) with a nearest neighbour classifier to predict correct or incorrect form.

B. Virtual Coach: Monitoring Exercises and Aerobic Dance Generation

In this research paper software application called virtual coach is proposed. Virtual Coach is designed for yoga, weightlifting, and cardio. Weightlifting section consists of strength-training exercises, with more focus involving dumbbells. for strength exercises call for repetitions and in yoga requires holding body in a pose. Maintaining the proper pose is for both yoga exercises and weightlifting.

Author uses a sequence-to-vector model to evaluate the user. The model is then fed with real-time input of user's frames. These evaluated poses are then fed to the sequence-to-vector model which outputs proper feedback for improving exercise form based on the evaluation.

For Yoga poses, they used vector geometry. It builds a geometric model which computes the body angles and compares them with the ground truth reference pose features. The model gives output as feedback identifying the good and bad points in the pose.

C. Infinity Yoga Tutor: Yoga Posture Detection and Correction System

In this paper, author propose Yoga Tutor, which is a yoga posture detection and correction system, uses a mobile-based approach for correcting improper yoga postures of the people who are doing yoga. This mobile based approach consists of both yoga pose detection and yoga pose correction abilities. Moreover, this system consists of giving visual instructions to the user in real time, which would help the user to maintain a proper asana throughout the practice.

In addition, the system also allows the user to select one of three difficulty levels which has different levels of accuracy threshold, to help beginners as well as experienced yogis to perform proper asanas. All these features help to guide user to do yoga in a safe way and achieve the best results from yoga. Latest development in technology helps and makes this cause much easier to succeed with various research already done on Human Activity Recognition (HAR). In this work author focused on how to use the above models not only to detect but to guide the user to successfully practice poses much closer to perfection.

IV. SYSTEM ARCHITECTURE

The high-level system design shows how the different computational components, APIs and clients will be laid out.

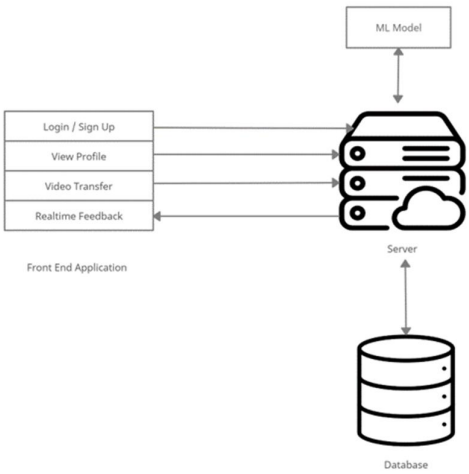

Figure 1: System Architecture Diagram

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V. ALGORITHMS

A. Pose Estimation Algorithm

We use the OpenPose technique created by Zhe Cao, Ginés Hidalgo, Yaadhav Raaj, Tomas Simon, Yaser Shikh, and Shih-En Wei for Pose Estimation OpenPose is a real-time multi-human pose recognition library that can recognize key points of the human body, feet, face and hands in a single image. Features Of OpenPose Library:

1. Real-time 3D single-person key-points detection
2. Real-time 2D multi-person key-points detection
3. Single-person tracking for speeding up the detection and visual smoothing
4. Calibration toolbox for the estimation of extrinsic, intrinsic, and distortion camera parameters

The OpenPose library first uses the first few layers to extract features from the image. The extracted features are input to two parallel partitions in the convolutional network layer. The first split predicts a set of 18 trust maps. Each map specifies a specific part of the human pose skeleton. The next branch predicts another set of 38 Part Affinity Fields (PAFs) that indicate the level of association between parts. Later steps are used to clean up the predictions made by the branch. Bipartite graphs between pairs of parts are created using trust maps. The PAF value truncates weak links in the bipartite graph. You can now use all the steps specified to estimate the skeleton of the human pose and associate it with each person in the image as follows:

1. Entire image as input
2. Two-branch CNN to jointly predict confidence maps for body part detection
3. Estimate part affinity fields for parts association
4. Set of bipartite matchings to associate body parts candidates
5. Assemble them into full-body poses for all people in the image

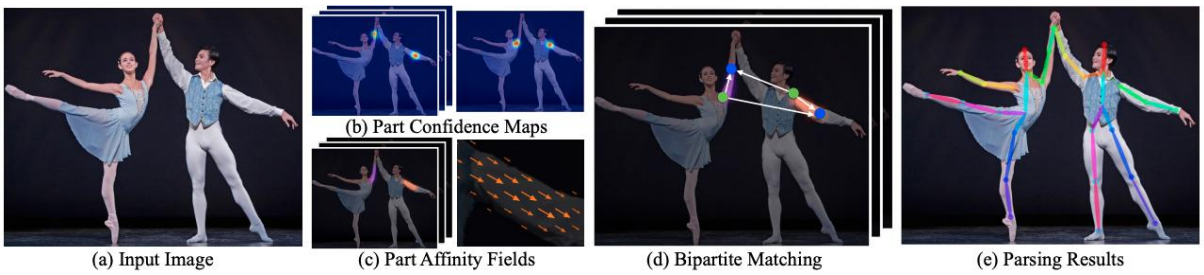

Figure 2: Working of OpenPose

B. Geometric Heuristic Algorithm

we compute body vectors from key points of interest, and use personal training guidelines and our own recorded videos to design geometric heuristics, evaluating on the body vectors.

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C. Example Bicep Curl

For biceps curl, we identify two interesting heuristics. First, do not move elbow while performing exercise. This is quantified by the angle between the upper arm vector and the torso vector. When the upper arm is stationary, there should be slight changes throughout the video and it should be parallel to the torso. If you move your upper arm a lot, the angle between the two vectors will change a lot.

Second, with proper full curl, you need to raise the weight beyond the centre (90 ° between the upper and forearms) where it normally stops until the biceps are fully contracted. This improper shape is usually due to the user using weights that are too heavy. This is what the application is showing. This problem is quantified by the minimum achievement angle between the upper arm.

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Forearm. At the starting position with the weight down, the angle is about 180 °. Lifting the weight reduces the angle until the user stops, and lowering the weight increases the angle again. Therefore, finding the minimum angle for the entire video sequence indicates how much the user has brought up weight.

Analysis of the annotated video data revealed that users rotate their upper arm excessively when the angle between the upper arm vector and the torso vector exceeds 35 °. For the minimum angle between the upper arms the vector and forearm vector are over 70 ◦, so the user will not completely wind up the weight. It uses quantified measurements and thresholds to specifically alert the user of which thresholds are being exceeded and provide suggestions for improving the form.

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VI. Conclusion

In this project, we introduced an end-to-end computer vision application that applies pose estimation, visual geometry, and machine learning to give personalized feedback on fitness exercise forms. We utilize the output of pose estimation to evaluate videos of exercises through human pose key points.

An Application Feeds a Live video to the server and provides Real-time feedback. It also keeps track of the Improvements made by the user in the cloud database to show progress.

VII. Future Scope

- To export proposed system to smartphones, building an application that allows users to get exercise pose feedback at real-time.
- To improve the pose feedback, providing specific suggestions on where the user's pose needs improvement (e.g., back, neck, shoulders), and suggesting targeted action.
- We could work on improved graphics, for instance, showing the user their labelled pose diagram, and comparing to the labelled pose diagram of a ground truth trainer.
- Feedback can be provided in audio format.

References

[1] Chen, Steven, and Richard R. Yang. "Pose Trainer: correcting exercise posture using pose estimation." arXiv preprint arXiv:2006.11718 (2020).
[2] Rishan, Fazil, et al. "Infinity Yoga Tutor: Yoga Posture Detection and Correction System." 2020 5th International Conference on Information Technology Research (ICITR). IEEE, 2020.
[3] Zheng, Ce, et al. "Deep learning-based human pose estimation: A survey. arXiv preprint arXiv:2012.13392 (2020).
[4] Cao, Zhe, et al. "Realtime multi-person 2d pose estimation using part affinity fields." Proceedings of the IEEE conference on computer vision and pattern recognition. 2017.
[5] Zell, B. Wandt, and B. Rosenhahn. Joint 3d human motion capture and physical analysis from monocular videos. In CVPR Workshops, 2017.
[6] G. Papandreou, T. Zhu, N. Kanazawa, A. Toshev, J. Tompson, C. Bregler, and K. Murphy. Towards accurate multi-person pose estimation in the wild. In CVPR, 2017.
[7] Jin, Sheng, et al. "Whole-body human pose estimation in the wild." European Conference on Computer Vision. Springer, Cham, 2020