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Accelerating Precision: Using AI to Fine-Tune Workout Form and Motion Speed

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***Abstract*— This is an extension of the paper that we published earlier on AI for workout Form Optimization. In the earlier paper, we presented a software solution for workout form optimization using joint angles. Just like the effectiveness of the workout is in the precision of the body form, it also gets hugely impacted by the workout speed, i.e., muscle contraction and relaxation speed. This paper covers a software solution that can be used to give users feedback on their workout speed for specific workout exercises. It uses computer vision and artificial intelligence libraries. The sample implementation is provided on GitHub GitHub - pythonioncoder/Fit-Form-AI.**

***Keywords*— Pose Detection AI Libraries, Media pipe, AI Programming, Computer Vision, Artificial Intelligence, Fit Form AI**

I. INTRODUCTION

Physical Workouts involve functional movement patterns. This involves concentric(lifting) movement and eccentric(lowering) movement. We are calculating muscle engagement time, the time spent between the concentric and eccentric phases of the movement. The muscle engagement speed is the number of repetitions of concentric and eccentric cycles per second.

Lifting weights rapidly engages fast-twitch muscle fibers, which can help improve muscle strength and explosiveness. These types of movements are used in activities that require sudden bursts of strength, such as rowing, powerlifting, boxing, and sprinting. Fast workouts can enhance muscle endurance and performance as one pushes himself to complete more repetitions in a shorter amount of time.

On the other hand, slow movements focus on controlled motion with a deliberate emphasis on concentric and eccentric phases. A person engages muscles for a longer time, leading to more time under tension by lifting and lowering weights slowly. This prolonged tension can help in muscle growth and hypertrophy. It also reduces the momentum that can cheat the muscles for their full workload. It can lead to better muscle activation and strength gains over time.

In recent times, software technologies for computer vision and artificial intelligence have become efficient and accurate. These can now detect and track the position and orientation of human body parts in images and videos. Using these libraries on images captured via the camera, the user can be guided from the initial body form to a target form.

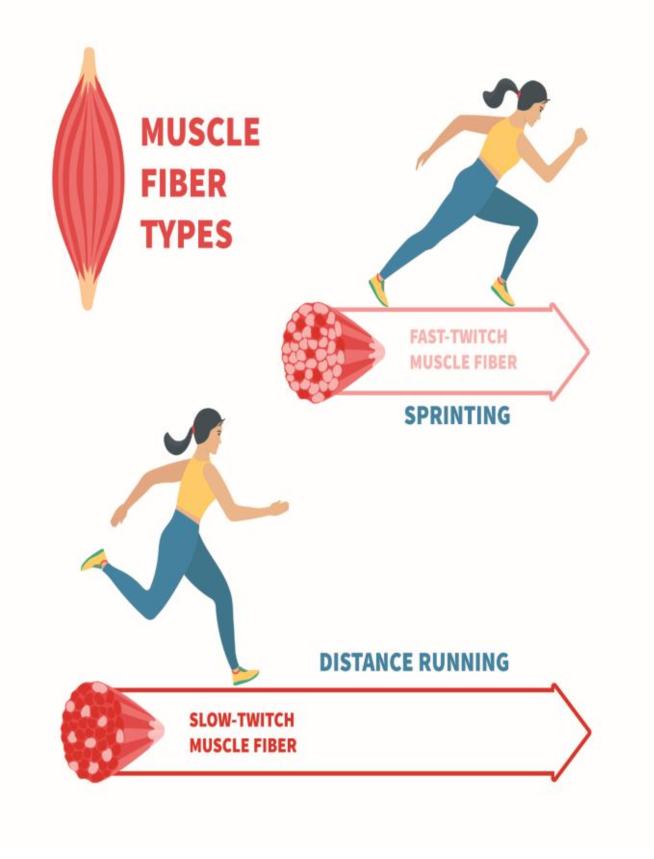

Fig 1: The speed of the Workout determines which muscle type gets engaged.

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Fig 2: Starting and Finishing Form for Bicep Curl Workout- An Isolation Workout

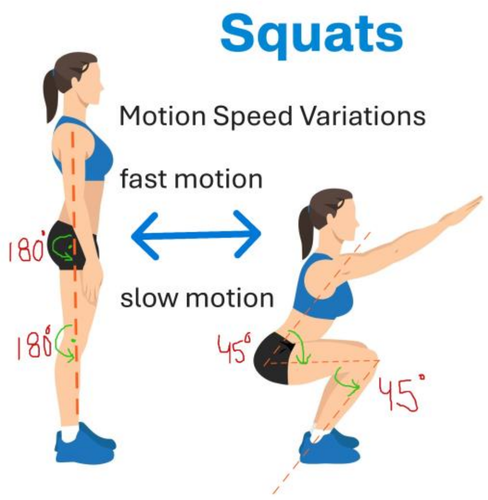

Fig 3: Starting and Finishing Form Angles for Squat Workout- A Compound Workout

II. HUMAN POSE DETECTION AND ESTIMATION

A. What

Pose detection and estimation is a feature of computer vision software that includes detection, association, and tracking of body parts' semantic points. For example, "right hand," "left shoulder," and "right knee." With the help of pose detection, computers can predict the poses of human body parts and joints.

B. Why and How

1) Technology

The performance of semantic point tracking in images and videos required high computational resources. With the advances in computer hardware and computational processing for AI, real-time image processing models are becoming economically and timewise feasible.

Various software libraries are available for pose detection-

1. OpenPose - OpenPose: Main Page (cmu-perceptual-computing-lab.github.io)

2. PoseDetection - Pose detection | ML Kit | Google for Developers

3. DensePose - DensePose

4. AlphaPose - GitHub - MVIG-SJTU/AlphaPose: Real-Time and Accurate Full-Body Multi-Person Pose Estimation&Tracking System

5. HRNet - HRNet · GitHub

6. MediaPipe Pose - Pose landmark detection guide | Google AI Edge | Google AI for Developers

Various pose libraries can estimate the human pose; Google AI library and media pipe pose landmark detection can be used to detect 33 key points. The key advantage of media pipe over other libraries is a rich set of output data points, efficiency, and accuracy. Media Pipe Pose is an ML solution for high-fidelity body pose detection, estimating 3D key points and background segmentation masks on the whole body from RGB video frames using BlazePose research.

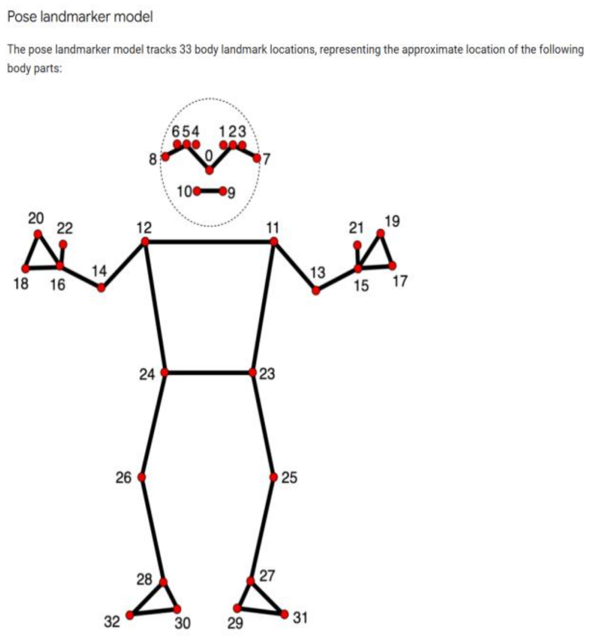

Fig3: Key points detected via media pipe library.

```
0 - nose
1 - left eye (inner)
2 - left eye
3 - left eye (outer)
4 - right eye (inner)
5 - right eye
6 - right eye (outer)
7 - left ear
8 - right ear
9 - mouth (left)
10 - mouth (right)
11 - left shoulder
12 - right shoulder
13 - left elbow
14 - right elbow
15 - left wrist
16 - right wrist
17 - left pinky
18 - right pinky
19 - left index
20 - right index
21 - left thumb
22 - right thumb
23 - left hip
24 - right hip
25 - left knee
26 - right knee
27 - left ankle
28 - right ankle
29 - left heel
30 - right heel
31 - left foot index
32 - right foot index
```

Fig4: Key points detected via media pipe library.

Convolutional Neural Networks (CNNs) are widely used in these software libraries. These libraries try to understand the geometric and motion information of the human body.

2) Solution Algorithm

As described in an earlier paper, the core algorithm of our software solution is to determine angles between various body parts using the output coordinates of the 33 key points mentioned above. These angles can be calculated using the distance formula and the Law of Cosines.

$$A = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

$$B = \sqrt{(x_2 - x_0)^2 + (y_2 - y_0)^2}$$

$$C = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2}$$

$$a = \cos^{-1}\left(\frac{A^2 - B^2 - C^2}{-2BC}\right)$$

Fig5: Calculating angle between 3 points (x0,y0), (x1,y1) and (x2,y2)

Using the calculated angles between the body parts, the user can be guided to an ideal body form for a selected workout.

We are calculating the rate of change of the joint angle per unit of time (for example, radians/sec) to estimate the speed of the motion. The benchmark speed for every workout is different, and corresponding relative slowness and fastness are calculated by using this benchmark speed.

C. Challenges

As the calculations are happening in real-time, the feedback

Because the human body's appearance can change due to various variables like clothing, viewing angle, and background, pose estimation has to be robust with real work variations. Bigger semantic points like arms, legs, neck, and head are relatively easy to detect and estimate, but smaller points like fingers and facial features can sometimes be difficult to detect and estimate.

The accuracy and effectiveness of our solution are directly proportional to the accuracy of the output data points given by the pose estimation library.

III. FUTURISTIC VIEW

There are many parameters that determine the correctness of any workout. Examples are wide/narrow stance, a mix of slow/fast motion, and rest-pause timing. Proper technique is important to avoid injury and get the most out of the workouts. We are trying to incorporate all these parameters in the FitForm AI to maximize the effectiveness of the software.

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