Form Correctness Detection

Smartan AI internship Task

Role : AI Intern

Author Name: Devisetty Sanjay Kumar

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1. Introduction :

This project contains the entire form-correctness detection pipeline, that is built by human pose estimation, which is done within the Smartan.AI internship assignment. The system detects body keypoints in a video showing a short exercise using MediaPipe Pose and calculates time-series joint angles, including where an angle of the elbows in a bicep curl. Once smoothing has been done to eliminate keypoint noise, a series of rule-based standards is employed to categorize each frame as a Good Rep, Too Low or Too Extended. The result is a video with annotations on feedback, as well as a CSV file with values of the angles and assessments. The paper reveals how computer vision and geometric analysis can be used to produce real-time and explainable exercise feedback.

2.Posture Rules:

1.Elbow Angle Rule (Bicep Curl Evaluation)

- Calculate shoulder elbow wrist angle.
- Form to corpus (Good Rep): 45deg <= angle <= 160deg
- Too Low: angle < 45deg - is not lifting to full.
- Too Extended: angle is greater than 160deg - risk of overextension and injury.

Why this rule matters:

It makes sure that the curl motion has remained within its effective and safe range of movement.

2.WristShoulder Alignment Rule (Lateral Raise Evaluation)

- Apply vertical difference: wristy- shouldery.
- Proper position: The position of a wrist is to be formed almost parallel with a shoulder.
- Incorrect form:

  Wrist elevated -> shoulder shrug -> bad biomechanic

  Wrist too low -> partial elevation.

Why this rule matters:

It helps to keep the arm in the right plane and does not allow over-loading upper trap.

3.Back Symmetry Rule (Posture Stability)

- Measurement of difference in the height of the shoe of the left shoulder and the right shoulder
- Right posture: Head level with shoulders.
- Wrong posture: Meaningful difference shows the presence of bending or twisting.

Why this rule matters:

It does not have a one-sided or unbalanced performance which can result in long term harm.

Logic Behind the Rules:

1. Elbow Angle Logic

- When you do a bicep , your arm bends at the elbow.
- If you don’t bend enough angle then the curl is **too low**.
- If you keep straighten your arm too much then the hand goes too far down →then too extended.
- A correct curl stays in a safe middle range.
  That’s why we check the elbow angle to see if the curl is done properly.

2. **Wrist–Shoulder Alignment Logic**

- When lifting your arm sideways your wrist should be at the same height as your shoulder.
- If the wrist is higher → you are shaking your shoulder → then wrong muscle used.
- If the wrist is lower →then you didn’t lift your arm fully.

3. **Back Symmetry Logic**
    - Your shoulders should stay in same level when exercising.
    - If one shoulder goes up or down more than the other,it means your back is bending or twisting.
    - This is a sign of **bad posture** and can cause injury.That's why we compare left and right shoulder positions for no danger.

3.Handling Multiple Persons and Edge cases:

Some videos are possible to have more than a single person, body joint absence, and sudden motions that bewilder the pose detection model. The system will choose whoever is nearest to the camera, or in the middle of the frame, to deal with cases of several individuals becoming part of the frame, since the individual who is commonly doing the exercise is usually in the center of the frame. In case there are any missing keypoints (like shoulder, elbow, or wrist) because of the occlusion or bad lighting, these frames are not counted as in the category of No detection so that it does not calculate the angle wrongly. To smooth shaky or jitter values due to little detection mistakes, the angle time-series is averaged with a moving average filter. In a scenario when a large number of frames are certified with low confidence, the system does not provide wrong feedback, instead, it holds onto the one before and maintains its stability. Such ways have been able to keep the system correct even when persons move fast, and partially exit the frame or when the quality of the video is not ideal.

4. Challenges & Future Work

A number of challenges were witnessed in the process of developing this project. In some cases, the pose detection model failed when the video was of low light, high velocity and some parts of the body were concealed. This led to the loss or inaccuracy of the keypoints which influenced the calculation of the angle. The other issue was the management of the jittery or shaky key points that needed to be smoothed in order to stabilise the feedback. There can be only one person in the video which also makes the system best, therefore multi-person detection is also not an option. The project can be enhanced in future by including better tracking systems to assist other individuals, through machine learning models to learn the proper and improper form automatically, increase the counting of reps, speed regulation, and posture rating. On top of that, the system can be made more personal and accurate by making the rules of body alignment more detailed and using AI methods to fit to various body types.

5.Conclusion

The project has been capable of illustrating a full process of evaluating exercise forms with the help of human pose estimation and rule-based analysis. Using MediaPipe to produce the coordinate of the keypoint and angle-based posture rules, the system delivers consistent, frame-based feedback, which demonstrates the right and the wrong patterns of movements. The implementation is also useful as it demonstrates that the integration of time-series joint analysis, smoothing methods, and geometric reasoning can lead to the development of a workable and interpretable way of arriving at a fitness assessment. Although the system itself works effectively with single-person videos and when the environment is controlled, some of the problems that could be resolved through improvement include occlusions, multi-person settings, and pose variations. The improvements in the future might be connectivity to multi-person tracking, learning-based scoring models, and additional more detailed posture metrics. All in all, this paper has established a high base of using intelligent exercise monitoring systems and shows how computer vision can be used to enhance safety, accuracy, and guidance to users in fitness purposes.