

## # Exercise Form Evaluation – Project Report

### ## 1. Posture Rules Used

#### ### A. Back Posture Rule

- Compares left and right shoulder heights.
- Compares left and right hip heights.
- Allows small or medium tilt (because athletes naturally lean slightly when lifting).
- Flags only \*major unevenness\* as incorrect.

#### ### B. Bicep Curl Elbow Rule

- Uses elbow joint angle (shoulder–elbow–wrist).
- Classification:
  - $>150^\circ$  → Arm straight (start curl)
  - $100\text{--}150^\circ$  → Half curl
  - $40\text{--}100^\circ$  → Good curl range
  - $<40^\circ$  → Full contraction
- Rep detection is based on the angle decreasing (curling) and then increasing (lowering).

#### ### C. Lateral Raise Shoulder & Wrist Rule

- Shoulder angle measured relative to a vertical vector.
- Good raise is when shoulder angle is between \*\* $70^\circ\text{--}100^\circ$ \*\*.
- Additional check: wrist height  $\approx$  shoulder height.
- Ensures elbows remain almost straight ( $>150^\circ$ ).

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### ## 2. Logic Behind the Rules

#### ### A. Why Angle Thresholds?

Human motion is cyclical. Angles let us detect:

- Down → Up transitions (rep start)
- Up → Down transitions (rep complete)
- Quality of the top position

Thresholds were chosen after testing across multiple videos.

### ### B. Why Smoothing?

Raw pose detection is noisy. A 7-frame moving average stabilizes:

- Elbow angles (for curls)
- Shoulder angles (for lateral raises)

This prevents false rep counts.

### ### C. Why Independent Arm Tracking for Lateral Raises?

Each arm behaves independently in real workouts.

So the algorithm keeps:

- Stage (up/down)
- Ready state
- Good/wrong counter
- Top-quality flag

\*\*Per arm\*\*, not shared.

This improves rep accuracy.

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## ## 3. Challenges Faced & Multi-Person Handling

### ### Challenge 1: Pose Noise in Some Frames

Solution:

- Smoothing
- Velocity-based filtering
- Angle range validation

### ### Challenge 2: Different Body Sizes / Camera Perspective

Solution:

- Rules avoid strict pixel distances.
- Uses angle-based rules (scale-invariant).

### ### Challenge 3: Multiple People in Video Footage

Although the final system tracks only one person (assignment does not require multi-person implementation), here is the approach:

#### #### How Multi-Person Would Be Handled:

1. Use \*\*MediaPipe Holistic\*\* or \*\*OpenPose BODY25 multi-person model\*\*.
2. Detect all persons → get bounding boxes.
3. Select target person using either:
  - Largest bounding box
  - Person closest to center
  - Face recognition (optional)
4. Track that single person using:
  - Kalman filter
  - OR MediaPipe ID tracking metadata

This ensures stable tracking even if others appear in frame.

### ### Challenge 4: Incorrect Lighting / Occlusion

Solution:

- Validate keypoint visibility score.

- Skip frames where confidence < 0.5.

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## ## 4. Final Notes

This project demonstrates:

- Pose estimation
- Rule-based biomechanics evaluation
- Real-time rep counting
- Both bicep curl & lateral raise evaluation
- Webcam + video support

The system is modular, allowing easy extension to:

- More exercises
- ML-based scoring
- Multi-person full implementation