Cricket Biomechanics: A Technical Guide

This document explains the technical approach used in the `Assignment.ipynb` notebook to analyze cricket batting biomechanics. The project is broken down into three main tasks: Biomechanical Analysis, Phase Segmentation, and Bat Path Analysis.

1. Biomechanical Analysis

This is the core of the project, focusing on the fundamental metrics of a player's stance and swing.

Technology

We use **MediaPipe Pose**, a powerful machine learning model that detects and tracks key body landmarks (like the shoulders, elbows, hips, and knees) in real-time. This is more efficient for single-player analysis than object trackers like DeepSORT, as we're interested in the body's pose, not its identity.

Metrics

We calculate the following metrics:

Elbow Angle: The angle formed by the shoulder, elbow, and wrist. A smooth, consistent angle indicates good control and a powerful swing.

Spine Lean: The angle of the player's torso relative to a vertical axis. This metric is crucial for assessing balance and head position. An ideal value is between 160° and 175°, indicating a healthy forward lean.

Head Horizontal Movement: The frame-to-frame change in the head's horizontal position. A lower value signifies a stable head, which is essential for watching the ball.

Foot Position: The horizontal position of the front foot. We track this to assess a player's footwork and how they move into the shot.

Reporting

All these metrics are saved to a JSON file (`metrics_log.json`). At the end, an AI model (Gemini API) processes these metrics to provide personalized coaching feedback in an `evaluation.json` file. A visual report is also created as a PNG file that charts elbow angle and spine lean over time, allowing for a detailed review of the player's consistency.

2. Automatic Phase Segmentation

This task divides the batting shot into distinct, understandable phases to provide a more contextual analysis.

Heuristics-Based Approach

The code uses a simple but effective state machine based on the vertical velocity of the batsman's and bowler's wrists to detect the phases.

Stance: The resting state before the bowler's delivery.

Pre-Swing: The period between the bowler's release and the batsman's downswing, identified by a significant downward movement of the bowler's wrist.

Downswing: The period where the batsman's wrist moves rapidly downwards to meet the ball.

Impact/Follow-through: The moment the wrist's velocity drops significantly or the elbow's angle is at its minimum, followed by the upward arc of the bat after contact.

Recovery: The final phase where the player returns to a balanced, ready position.

Slow-Motion Effect

The video output (`output_phase_seg.mp4`) applies a slow-motion effect to the `Pre-Swing` and `Downswing` phases, highlighting these critical moments for detailed review, similar to a broadcast replay.

3. Bat Path Analysis

This part of the analysis focuses on the trajectory and angle of the bat during the swing.

Approximation

Since we can't directly detect the bat, we **approximate its position** by extending a line from the player's elbow through their wrist. We assume the bat is aligned with the forearm during the swing.

Metrics

The key metric calculated here is the **swing angle**, which is the angle of the approximated bat relative to a vertical axis. This provides insight into the straightness of the bat and the shape of the swing. A straighter bat path is generally preferred for controlled shots.

Visualization

The output video (`bat_swing_analysis.mp4`) visually overlays a cyan line and a circle to represent the bat, with the swing angle displayed in real-time. This provides a clear, visual representation of the swing path and trajectory.