Comparative Evaluation of Player Tracking Systems for Tactical Camera Football Analysis

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This project systematically compares four player tracking systems for extracting trajectory data from football videos recorded with tactical cameras, which provide a fixed, elevated full-field view. The evaluated systems are Eagle, YOLOv8 + ByteTrack (Darkmyter), YOLOv5 + OpenCV (AnshChoudhary), and the modular TrackLab framework. Evaluation combines physics-based trajectory metrics, cross-system agreement, and qualitative visual inspection. The goal is to identify the most reliable system for generating accurate and consistent trajectories to support later analyses of how collective player movements influence goal-scoring opportunities.

CCS Concepts: • **Computing methodologies** → **Tracking**; *Motion capture*; • **Information systems** → Sports analytics.

Additional Key Words and Phrases: Player tracking, Computer vision, Tactical camera, Multi-object tracking, Sports analytics, Trajectory analysis, YOLOv8, ByteTrack, BoT-SORT, Homography, Football analytics

1 Introduction

Football analytics has advanced rapidly with modern computer vision and tracking technologies. While professional teams use multi-camera systems, single tactical cameras provide fixed, elevated views of the full pitch offer a more accessible yet underexplored data source. This project evaluates four existing player-tracking systems to identify which performs best on tactical camera footage. Rather than developing a new model, the aim is to determine and optimize the most effective existing approach for accurate, continuous tracking, providing a foundation for future tactical analysis of team movements.

2 Systems Under Evaluation

We evaluate four open-source systems representing different architectural approaches:

Eagle: End-to-end pipeline with YOLOv8 detection, BoT-SORT tracking, HRNet keypoint detection, automatic homography calculation, and team assignment. The most mature, feature-complete solution.

Darkmyter: YOLOv8 + ByteTrack with dual-threshold detection strategy maintaining tracks using both high and low confidence detections.

AnshChoudhary: YOLOv5 + OpenCV pipeline integrating pixel segmentation, optical flow, perspective transformation, and KMeans-based team assignment.

TrackLab: Modular framework supporting multiple detectors (YOLOv5/v8/v11, YOLOX, RTMDet), trackers (DeepSORT, ByteTrack, OC-SORT, BoT-SORT), and pose estimators. Enables testing detector-tracker combinations.

All systems will be used as-is with minimal modifications, focusing on comparative performance.

3 Methodology

To evaluate tracking systems without manual annotations, we use a multi-pronged approach: quantitative metrics, cross-system comparison, and qualitative assessment.

3.1 Quantitative Metrics

- **Trajectory Smoothness:** Jerk score (third derivative of position); lower values indicate more natural motion.
- **Speed Plausibility:** Share of segments exceeding human physical limits (e.g., >40 km/h, >5 m/s^2).
- **Detection Completeness:** Frame coverage with 20–22 players, track durations, fragmentation rate.

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3.2 Inter-System Agreement

To evaluate consistency across systems without manual ground truth, we compare their outputs on a frame-by-frame basis using the following metrics:

- **Position Distance:** For each player, we compute the Euclidean distance between predicted positions across systems. Smaller distances indicate stronger agreement on player location.
- **Bounding Box Overlap (IoU):** We calculate the Intersection over Union (IoU) between bounding boxes produced by different systems. Higher IoU values suggest similar detection accuracy.
- **Velocity Correlation:** We measure how well each system's velocity estimates for a given player align over time. High correlation indicates consistent interpretation of movement patterns.
- **Disagreement Zones:** We identify frames or regions where systems diverge significantly in their predictions. These highlight challenging tracking scenarios.

3.3 Qualitative Assessment

Three 30-second clips are rated (1–5 scale) on continuity, identity consistency, realism, occlusion handling, team labeling, and edge-case performance using side-by-side visualizations.

3.4 System Selection Strategy

The results from the quantitative metrics and inter-system agreement analysis will be compiled into a weighted scoring matrix to compare overall system performance. Each metric (e.g., smoothness, completeness, identity consistency) will be scored and normalized, and systems will be ranked accordingly.

The best-performing system will be selected based on:

- Consistently high scores across all evaluation categories
- Robustness under tactical camera conditions (e.g., fixed angles, long-range visibility)
- Stability in player identities and trajectory continuity

4 Implementation

4.1 Data Sources

We will use publicly available tactical camera footage from YouTube. These videos typically offer a fixed, elevated, full-pitch view suitable for consistent player tracking. The goal is to collect 3–5 full matches (approximately 90 minutes each) for comprehensive system evaluations.

4.2 Optimization Strategies

- **Reuse a single homography matrix:** Since tactical cameras are fixed, compute one transformation (via `cv2.findHomography`) using 4–8 field landmarks and apply it to all frames for faster, consistent mapping.
- **Adjust detection thresholds:** Lower confidence thresholds and raise input resolution to better detect small, distant players without flooding with false positives.
- **Tune tracking parameters for full-field view:** Extend track lifespan, increase re-identification distance, and refine IoU thresholds since players remain visible and occlusions are brief.
- **Apply trajectory smoothing:** Use Kalman filters, moving averages, or splines to stabilize movement paths while preserving realistic motion.

5 Deliverables

- Comparative evaluation report analyzing all four systems
- Evaluation codebase for metrics and visualizations