Brief Report: Soccer Player Tracking and Re-Identification Using YOLOv11

1. Approach and Methodology

The goal of this project was to track soccer players from a 15-second video clip using a fine-tuned YOLOv11 object detection model. The system needed to assign consistent IDs to players, even when they temporarily left the frame and returned.

- I used **Ultralytics YOLOv11** to detect three object classes: `player`, `referee`, and `ball`.
- The input video was processed frame by frame.
- I implemented a **centroid-based tracking algorithm**, which calculates the center of each detected bounding box and matches it with previously tracked objects based on distance.
- A simple ID management system was used to persist player identities over time.
- Detected and tracked objects were visualized and saved in:
    - `output_tracked_video.mp4`: annotated video output.
    - `player_tracking_data.csv`: frame-wise record of player ID, label, and bounding box.

2. Techniques Tried and Their Outcomes

Several techniques were explored to improve the consistency and reliability of tracking:

- **Frame-by-frame detection**: Worked for bounding boxes but couldn't maintain consistent IDs — every frame treated as a fresh detection.
- **Centroid-based matching**: Simple, fast, and effective in low-overlap scenes. IDs were preserved as long as players didn’t overlap or exit for too long.
- **Deep SORT integration**: Tried for better re-identification using appearance and motion tracking. Resulted in:
    - Better ID consistency.
    - Occasional **duplicate tracking** due to overlapping YOLO detections.

- **Non-Maximum Suppression (NMS)**: Applied manually before tracking to remove duplicate/overlapping boxes. This significantly reduced false positive tracks.

3. Challenges Encountered

Some of the key challenges during development included:

- **Duplicate bounding boxes**: YOLO sometimes detected multiple overlapping boxes for the same player, confusing the tracker.

- **ID swapping**: When players crossed paths or moved in groups, the tracker occasionally reassigned IDs incorrectly.

- **Real-time performance**: Balancing high accuracy with low latency was tricky, especially when using Deep SORT.

- **Referee and ball detection**: While detectable, they were not included in the CSV initially, limiting full scene analysis.

4. Current Status and What Remains

The current version of the project achieves basic, functional tracking with reasonably accurate player IDs and outputs both video and structured CSV data.

However, some elements remain incomplete:

- **Referee and ball tracking in CSV**: Only player data is currently logged.

- **Robust Deep SORT integration**: Needs tuning for custom re-identification embedding and better duplicate handling.

- **Occlusion handling**: In complex scenes, players moving close together can still confuse the ID tracker.

- **Movement analytics**: Heatmap generation and trajectory plots are planned but not implemented.

5. Future Steps to Solve Outstanding Issues

To address the remaining challenges and finalize the implementation:

- I will improve detection quality by filtering with **class-wise NMS** and adjusting YOLO confidence thresholds.

- Deep SORT will be further tuned using a **custom appearance model** or reduced embedding sensitivity.

- Ball and referee tracking will be included in both **video output and CSV logs**.

- I will extract positional data per player to **generate movement heatmaps**, which can be useful for tactical analysis.