Player Re-Identification in Broadcast Football Footage

Objective

The objective of this project is to develop a robust and real-time system that detects and consistently tracks football players in broadcast videos. The key challenge addressed is maintaining a unique and persistent identity (ID) for each player across frames, even if the player exits the frame due to occlusion or camera panning and later re-enters.

Methodology

1. **Detection**

   - Model Used: YOLOv8 (custom-trained weights: `best.pt`)
   - Purpose: Detect players, referees, goalkeepers, and the ball
   - Confidence Threshold**:** 0.4
   - Output: Annotated frames and a detection-only video (`detected_video_custom.mp4`)

2. **Tracking and Re-Identification**

Initially, the system combined YOLOv8 with ByteTrack to associate IDs across frames. However, this failed to maintain consistent player identities when players left the frame and returned later, especially during overlaps or occlusion events.

To address this, I integrated a visual Re-Identification module using the Torchreid model `osnet_x1_0`, which extracts appearance embeddings from each detected player's bounding box. These embeddings are matched against a stored gallery of previously seen players using cosine similarity.

   - **Gallery Logic**:
     - `active_tracks`: Currently visible players
     - `inactive_gallery`: Lost or occluded players retained for re-matching
   - **ID Assignment**:
     - If a current frame's embedding closely matches a stored one (similarity > 0.7), the previous ID is reassigned
     - Otherwise, a new global ID is created and registered

This allowed consistent player IDs across **consecutive frames**, but I was **not fully successful in reassigning the same ID to a player once they left the frame and re-entered after a long interval**. While identity was maintained when the gap was small, full re-identification after long-term disappearance remains an open challenge.

Techniques Tried

Successfully Implemented:

- Visual Re-ID using Torchreid with `osnet_x1_0`
- Cosine similarity matching with threshold-based re-assignment
- Track memory and ID gallery for short-term reactivation
- Annotated output video generation with global player IDs

Attempted but Unsuccessful:

Method	Limitation
YOLO + ByteTrack only	Frequent ID switching during occlusion or path crossing
IOU/Spatial proximity-based matching	Failed when players moved closely or erratically
ByteTrack buffer tuning	Did not resolve re-ID after long disappearances
Manual feature buffer tracking	Inefficient and not scalable
Re-ID without gallery filtering	Caused ID collisions and false matches
Long-term Re-ID recovery after re-entry	Only partially worked; inconsistent ID matching over time

Challenges Encountered

- Re-Entry Re-ID Failure**:** The system could not reliably reassign the same ID to a player who re-entered after being out of frame for several seconds.
- Overlapping Players**:** Players with similar appearances (e.g., same team jerseys) resulted in false re-identifications.
- Feature Degradation: Crops during motion blur or occlusion resulted in weak embeddings, making feature matching unreliable.

What Remains & Next Steps (If More Time/Resources Were Available)

- **Improve ID Persistence After Re-Entry**: The system currently struggles to assign the same ID to a player who leaves and re-enters the frame after several seconds. Better re-identification logic or model fine-tuning is needed.
- **Train a Football-Specific Re-ID Model**: Using jersey numbers, team logos, and body shape could improve accuracy and help distinguish similar-looking players.

- **Add Motion Prediction**: Incorporating tracking techniques like Kalman Filters would improve ID continuity during brief occlusions.
- **Optimize for Speed**: Using tools like TensorRT or ONNX can help reduce processing time and enable real-time performance.
- **Extend to Multi-Camera Setups**: With more resources, the system could be expanded to handle cross-camera re-identification for full-match coverage.

Output Summary

- `detected_video_custom.mp4`: Detection-only output
- `tracked_video_reid_final.mp4`: Output with global player IDs
- Annotated frames saved under `output/detected_frames/` and `output/tracked_frames/`

Conclusion

This project demonstrates a robust and extensible approach to player tracking in sports broadcasts using object detection and visual Re-Identification. While identity consistency across consecutive frames was successfully maintained, long-term re-identification after players left and re-entered the frame remains an area for improvement. The current pipeline forms a strong foundation for real-time sports analytics and can be extended with advanced modeling and domain-specific training for greater reliability.