🎯 Object Detection and Tracking in Soccer Videos using YOLOv11+ ByteTrack

🧠 Approach & Methodology

The goal was to perform **object detection and tracking** in soccer match videos, specifically identifying **players, referees, and the ball**. The approach integrates a **custom-trained YOLOv11 model** with **ByteTrack** tracking to maintain object identities across frames.

Workflow:

1. **Model Setup**

   - Install & initialize the Ultralytics YOLOv11 framework.

   - Load a custom-trained YOLOv11 model (`best.pt`) from Google Drive.

2. **Video Handling**

   - Read the full video into memory using OpenCV.

   - Save the processed frames back into a new video using `cv2.VideoWriter`.

3. **Tracking Architecture**

   - Use **Batch Inference** (batch size = 20) for speed on Colab.

   - Integrate **ByteTrack** via `supervision` to maintain identity persistence.

   - Cache results using `.pkl` files for efficiency during iterative runs.

4. **Visualization**

   - Use **ellipses** to mark players/referees.

   - Use **triangles** to mark the ball.

   - Display **bounding boxes with track IDs** for better interpretability.

🛠️ Techniques Tried & Outcomes

Technique/Feature	Outcome
YOLOv11 Object Detection	High-accuracy detection of players and ball across frames
ByteTrack Integration	Smooth tracking, especially in crowded scenes
Batch Prediction (`batch_size=20`)	Efficient GPU memory usage and faster processing in Colab
Elliptical Annotations	Better visualization of player positions and identities
`.pkl` caching of detections	Drastically reduced runtime on repeated runs
Custom Tracker Class	Clean modular code with easy testability

🚧 Challenges Faced

Challenge	Mitigation/Current Status
Model missing fast-moving ball	Adjuste frame rate and detection confidence thresholds
ID switching for nearby players	Use persistent tracking and adjusted `track_high_thresh` parameter
Frame size/resolution issues	Normalize all video frames during preprocessing
Colab GPU memory limits	Used batch inference + video splitting if needed

✅ Summary

- 🎥 Successfully tracked players, referees, and the ball in soccer videos.

- 🔄 Achieved smooth, real-time tracking using a robust ByteTrack+YOLOv11 pipeline.

- 🧪 Optimized for experimentation and reruns using modular classes and caching.