

Object Detection and Tracking in Football Videos

Introduction

This project addresses the problem of detecting and tracking entities in football match footage. The objective was to identify players, referees, and the ball accurately across video frames, and assign consistent IDs to players. An additional constraint was to ensure that only one ball is tracked at any given moment, despite potential duplicate detections. The project aims to simulate a real-world pipeline for multi-object tracking under resource and time constraints.

Goals

- Detect players, referees, and the ball in football videos using a custom object detection model.
- Assign consistent tracking IDs to each player throughout the video.
- Ensure only one instance of the ball is tracked per frame.
- Deliver a clean, reproducible codebase with documentation and a report.

Tools and Technologies Used

- Python 3.10
- YOLOv8 (Ultralytics) - for object detection
- SORT (Simple Online and Realtime Tracker) - for multi-object tracking
- OpenCV - for video processing and visualization
- Git & GitHub - for version control and code submission

Approach and Methodology

1. Custom YOLOv8 Training: A YOLOv8 model was trained on labeled football video data to detect three object classes: player, referee, and ball.

2. Detection Pipeline:

- Each frame from the video is passed to the YOLO model.
- The detections are filtered by class and confidence thresholds.
- The output is formatted into [x1, y1, x2, y2, confidence, class] format for tracking.

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3. Tracking with SORT:

- The SORT algorithm is used to track detections across frames.
- It assigns unique IDs to each detected object and keeps track of their motion.
- The logic was extended to maintain the same ID for each player and track only one ball using the highest-confidence detection.

4. Post-processing and Visualization:

- Bounding boxes and IDs are overlaid on each frame using OpenCV.
- A new output video with tracked detections is saved for demonstration.

Techniques Attempted and Their Outcomes

- Tried different combinations of SORT parameters to reduce ID switching.
- Added logic to prevent multiple balls being tracked in one frame.
- Modified error-prone parts of the SORT implementation.
- Experimented with Kalman filter tuning but did not finalize due to limited time.

Challenges Encountered

- Inconsistent IDs in SORT when detections were missed or overlapped.
- Duplicate ball detections by YOLO that confused the tracker.
- Ensuring stability of the SORT algorithm with fluctuating detection counts.
- Integration of YOLOv8 with custom classes and training required careful setup.

Remaining Work and Future Improvements

- Integrate a more advanced tracking algorithm like Deep SORT or ByteTrack.
- Improve YOLO training data for higher detection accuracy.
- Add jersey number recognition for better player ID assignment.
- Optimize runtime using batch inference and CUDA.
- Enable frame-skipping or multi-threaded decoding for speed.

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Submission Structure

- The GitHub repository contains:
 - All source code including detection, tracking, and visualization.
 - A README file with clear setup and usage instructions.
- The trained YOLOv8 model (best.pt) for inference.
- This project report (in PDF and Markdown formats).

Conclusion

This project demonstrates a working solution for object detection and tracking in sports video analytics using open-source tools. It handles key challenges like identity consistency and object uniqueness (for the ball), and provides a reproducible pipeline that could be extended with more advanced techniques.