

MIT 6.S058: Object Tracking in Sports

Term Project Proposal

Spring 2026

1 Introduction

In professional sports analytics, “ball trails” and “player heatmaps” are generated by tracking objects in real-time. This project focuses on the challenge of maintaining unique IDs for multiple objects over time, and possibly predicting their next position. The underlying architecture of this project is identical to the systems used in advanced robotics and autonomous vehicle safety.

This project explores making a hand-crafted kinematic models, with the option to compare against modern end-to-end deep learning architectures like YOLO [7]. Whether the goal is to derive high-level performance metrics for sports analytics or to enable a vehicle to predict and avoid a collision, mastering these temporal consistency techniques is essential for building machines that can reason about a moving world.

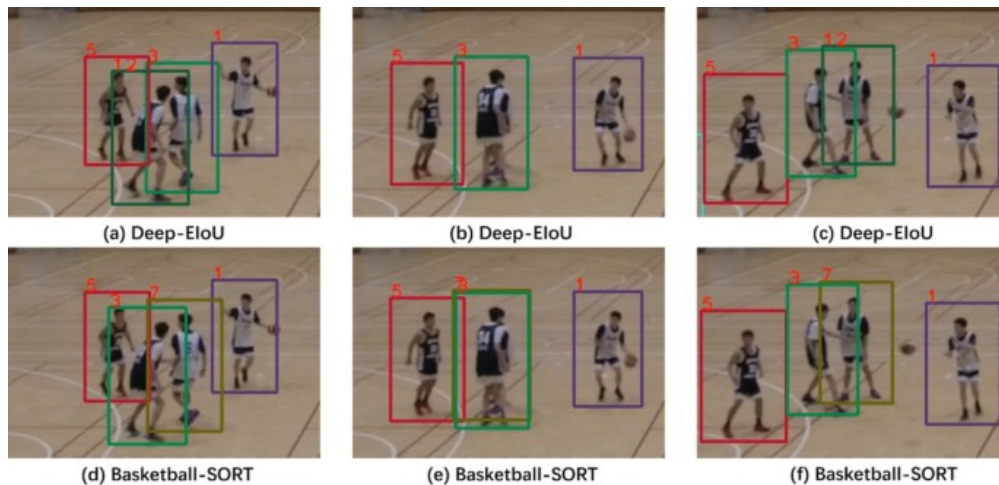


Figure 1: Object tracking in Basketball. Source: Basketball-SORT.

2 Problem Statement

Build a system that identifies players and balls in a sports videos as they move, and predicts their future trajectories N frames into the future. Expand your tracking abilities by maintaining player’s unique identities (ID) in multi-object tracking

Note: Object tracking has many great uses and a vast assortment of compiled datasets, feel free to find an application which most interests you.

3 Methodology Options

Choose and justify your implementation for the following modules:

3.1 The Detection Challenge

How will you identify your object? Possible options below:

- **Background Subtraction:** Implement a classical foreground-background model. How will you handle shadows and camera jitter?
- **Color/HSV Masking** Design a detector for specific objects (e.g., a yellow tennis ball or jersey colors). How do you handle changing lighting?

3.2 The Tracking & Association Challenge

- **Motion Model:** Try implementing a Kalman Filter [4], optical flow [1] or one of the methods mentioned in OpenCV Object Tracking Project to track state $[x, y, \dot{x}, \dot{y}]^T$.
- **Data Association:** If you can successfully track one object, try solving the “assignment problem” to track multiple objects. How do you prevent ID switches when players cross?

3.3 Prediction Challenge

Using your tracking, try predicting where your object(s) go next. How well does your model do against true future frames?

4 Resources

- **Potential Datasets:** SportsMOT [3] or SoccerNet [6]. Note: you should start with videos that have stationary cameras.
- **Technical Guide:** OpenCV Object Tracking.
- **Logic Reference:** Simple Online and Realtime Tracking (SORT) [2] - The standard for Kalman-based association.
Implementing SORT in Python
- **Modern Object Tracking Model** YOLO Multi-Object Tracking [7] - has an out of box tracking feature that you can compare with your implementation (also fun to experiment with!)

5 Expansion Ideas

- Incorporate physics! Can you add a constant downward acceleration term (g) to your Kalman filter [4] to better predict the parabolic arc of a ball in flight?
- Can you use your next-location prediction to help guide your tracking?

- How does your implementation compare with modern deep learning models? Where might your model be more efficient, and where might your model struggle?
- What are ways you can improve your multi object data assignments?

6 References

References

- [1] Advanced Computer Vision – Motion Estimation With Optical Flow <https://datahacker.rs/002-advanced-computer-vision-motion-estimation-with-optical-flow/>
- [2] Bewley, A., Ge, Z., Ott, L., Ramos, F., & Upcroft, B. (2016). *Simple Online and Realtime Tracking*. IEEE International Conference on Image Processing (ICIP). <https://arxiv.org/abs/1602.00763>
- [3] Cui, Y., et al. (2023). *SportsMOT: A Large-scale Multi-Object Tracking Dataset in Multiple Sports Scenes*. arXiv preprint arXiv:2304.05139.
- [4] Kalman, R. E. (1960). *A New Approach to Linear Filtering and Prediction Problems*. Transactions of the ASME–Journal of Basic Engineering, 82(Series D), 35-45.
- [5] Kuhn, H. W. (1955). *The Hungarian Method for the Assignment Problem*. Naval Research Logistics Quarterly, 2, 83-97.
- [6] Deliege, A., et al. (2021). *SoccerNet-v2: A Dataset and Benchmarks for Holistic Understanding of Broadcast Soccer Videos*. CVPR Workshops.
- [7] Jocher, G., et al. (2023). *Ultralytics YOLOv8*. <https://github.com/ultralytics/ultralytics>