Re-Identification in a single feed

1. Overview & Pipeline

We built a robust, end-to-end re-identification system that assigns consistent IDs to players—even under occlusion, collisions, and entry/exit—in a 15-second clip.

1. **Detection**

   - Fine-tuned YOLOv11 (via Ultralytics code) to output only the "player" class.

   - Confidence threshold 0.25, IoU filter 0.5.

2. **Feature Extraction**

   - Deep CNN (MobileNetV2) backbone from PyTorch for 1,280-D appearance embeddings.

   - Crops are resized to 128×256, then L2-normalized.

3. **Jersey OCR**

   - Preprocess each crop (CLAHE, sharpening, adaptive threshold).

   - Tesseract in single-char mode (--psm 10) with digit-whitelist.

   - Track-level history of 5 frames; jersey confirmed once all 5 match.

4. **Tracking & Data Association**

   - **Kalman filter** (8-state constant-velocity) predicts each track's bounding box and speed.

   - **Cost matrix** combines three terms:

     - $0.4 \times (1 - \text{IoU(predicted, detected)})$

     - $0.4 \times (1 - \text{cosine(appearance)})$

- ■ 0.2 × (jersey‑match penalty: 0 if same, 1 otherwise)

  - ○ **Motion gating**: any detection whose center jumps beyond 1.5× predicted speed (or a 30‑px minimum) is disallowed.

  - ○ **Hungarian assignment** on gated cost matrix; unmatched detections spawn *tentative* tracks.

5. **Track Lifecycle Management**

   - ○ **Confirmation**: tracks require 3 consecutive hits before moving from TENTATIVE to CONFIRMED.

   - ○ **Survival**: confirmed tracks remain alive for up to 50 missed frames before deletion.

   - ○ **Output filtering**: only report tracks that have been confirmed *and* persisted for at least 5 frames, eliminating ghost IDs.

   - ○ **Dead‑track cooldown**: after a track is deleted, its ID is barred from being reassigned for 50 frames, preventing immediate ID reuse.

2. Experimental Techniques & Rationale

- ● **HSV histograms → CNN embeddings**
  Switched from 96‑D color histograms to 1,280‑D MobileNetV2 features. Learned embeddings vastly improve discrimination under similar kits and partial occlusions.

- ● **Single‑char OCR + temporal smoothing**
  Running Tesseract in --psm 10 mode on well‑preprocessed crops gave cleaner digit reads. Holding a 5‑frame majority vote stabilizes jersey assignments.

- ● **Motion gating**
  Filters out implausible associations when two players collide, leveraging the Kalman‑estimated velocity. This dramatically cuts swap rates during overlaps.

- ● **Output gating & cooldown**
  Delaying track outputs until stable prevents showing fleeting, noisy IDs. The dead‑track cooldown stops brand‑new players from inheriting old IDs.

3. Remaining Challenges & Future Work

- **Full occlusions** still occasionally cause ID gaps when a player lingers off-frame longer than the cooldown.

- **Heavy overlaps** in dense scenes can overwhelm motion gating.

- **OCR failure** on extreme motion blur.

Next steps could include:

- Integrating a specialized person re-ID network (e.g. OSNet) trained on player datasets.

- Adding a "merge-and-split" handler for two-into-one collision blobs.

- Extending the cooldown logic to incorporate appearance confidence for smarter ID revival.