Object Tracking & Re-Identification - One-Page Reference

Following an object on one camera and across many: how it works, how accurate it really is, and the privacy line. Representative 2025-2026 figures - all move with camera spacing, lighting, viewpoint, and time.

A. Tracking vs re-identification

- Tracking links a detected object frame to frame within one camera into a continuous track with a stable ID - it adds memory to detection.
- Tracking-by-detection: detect each frame, then associate (Kalman filter predicts motion; Hungarian algorithm matches boxes to tracks). ByteTrack, BoT-SORT.
- Re-identification recognizes the SAME object again on a different, non-overlapping camera by matching an appearance signature - not a face or a plate.
- Cross-camera tracking (MTMC) stacks three problems: single-camera tracking + re-ID + network-wide stitching. Each layer adds error.

B. Accuracy is a range, and it drops between cameras

- Metrics: MOTA = detection quality; IDF1 = how consistently each object keeps the same ID; HOTA = the balance of detection and association.
- Single-camera (MOT17): ~80% MOTA, 77-80% IDF1, 63-65% HOTA (ByteTrack, BoT-SORT). Re-ID retrieval clean set (Market-1501): ~96% Rank-1.
- Cross-camera tracking falls to ~70-85% IDF1; city-scale end-to-end HOTA can drop to ~45%. The harder MSMT17 re-ID set drops to ~86-87% Rank-1.
- Never accept 'we track your whole site at 99%'. Ask for the cross-camera identity score (IDF1/HOTA) on a layout like yours. Never 100%.

C. How a track surfaces - and the ONVIF caveat

- ONVIF Profile M carries analytics metadata; the scene description gives each tracked object an ObjectId (with Rename / Split / Merge / Delete operations).
- CAVEAT: the ObjectId is LOCAL to one device. Camera A's 'object 7' and Camera B's 'object 7' are unrelated - ONVIF does not standardize cross-camera identity.
- Stitching tracks across the camera network is the VMS's or a dedicated analytics layer's job - that is where the vendor's software and tuning live.
- ONVIF conformance is a baseline, not a guarantee that cross-camera tracking works out of the box.

D. Where it runs

- Single-camera tracking is light (Kalman + Hungarian) and runs in real time at the EDGE - the camera's NPU or a small on-site box.
- Cross-camera re-ID runs on a SERVER or in the CLOUD: to match across cameras, something has to see all of them at once, and the embedding model wants more compute.
- Central re-ID means sending appearance signatures (small) or crops (larger) up from every camera - bandwidth, plus a concentrated who-was-where index.
- More at the edge cuts bandwidth and keeps raw video on-device but limits how richly you can match across the network.

E. The privacy line: a trail is personal data

- A persistent cross-camera trail singles a person out across space and time, so it is PERSONAL DATA under GDPR Art. 4(1) even with no name attached.
- Appearance re-ID (clothing, shape) is generally NOT special-category biometric data (EDPB soft-biometrics view). Low-to-medium privacy weight.
- Face recognition and gait recognition DO uniquely identify - biometric data under GDPR Art. 9, a legal gate (also EU AI Act; real-time public RBI is prohibited since Feb 2025).
- Systematic large-scale tracking of a public space typically needs a DPIA (GDPR Art. 35). Engineering guidance, not legal advice - confirm with qualified counsel.

The clean rule: following the red jacket is not the same as naming the person - but the trail it builds is still personal data, and adding a face or a gait signature turns it into biometric identification. The tracker and re-ID MODEL (ByteTrack/BoT-SORT association, appearance-embedding/metric learning) is engineered in the AI for Video Engineering section; this is the surveillance APPLICATION. Sources: ONVIF Profile M and Analytics Service Spec (ObjectId / ObjectTree); GDPR Reg. (EU) 2016/679 Art. 4(1), 9, 35; EDPB Guidelines 3/2019; EU AI Act Reg. (EU) 2024/1689 Art. 5; ByteTrack (arXiv 2110.06864); BoT-SORT (arXiv 2206.14651); Ristani et al. CVPR 2018; CityFlow / AI City Challenge; HOTA (IJCV 2021).