1. Task Definition

Develop an automated intersection monitoring system using fixed-camera footage that:

1. Detects and tracks vehicles through the crossroads.
2. Identifies entry/exit lanes for each vehicle.
3. Detects anomalous behaviors including speeding, unusual trajectories, and pedestrians in restricted zones.

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2. Preliminary Plan

Speed Estimation:
Speed will be estimated from pixel displacement between frames, scaled using a homography-based conversion from pixel distances to real-world meters. If obtaining accurate camera calibration is difficult, we will instead evaluate speed relatively (e.g., "top 10% fastest vehicles") rather than absolute km/h.

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3. Evaluation Plan (expanded as requested)

3.1 Dataset

- UA-DETRAC for detection and tracking evaluation.
- For lane assignment and anomaly detection (speeding, odd trajectories), we will use:
    - Our own manual annotations on a small subset (10–20 short clips), because DETRAC does not include lane definitions or anomaly labels.

3.2 Evaluation Metrics

3.2.1 Tracking Evaluation (unchanged)

- MOTA, MOTP, IDF1, ID Switches

3.2.2 Lane Assignment Evaluation (NEW)

Since UA-DETRAC does not include lane information, we will create a small labeled dataset:
Procedure:

- We manually define lane polygons for 1–2 intersections.
- For ~200–300 vehicle tracks, we manually assign:
    - Entry lane
    - Exit lane

Metrics:

- Lane Assignment Accuracy (LAA): % of vehicles correctly assigned both entry & exit lanes.
- Confusion matrix per lane (useful if some lanes are ambiguous).

Expected difficulty:
Because we are beginners, we will keep lane definitions simple (4–6 polygons per intersection).

3.2.3 Speed Estimation Evaluation (NEW)

We will test speed estimation in two possible ways, depending on difficulty:

Option A – Absolute Speed (if calibration is feasible)

Using homography from at least 4 points with known real-world distances.
Ground Truth:

- We manually annotate timestamps for a small set of vehicles moving through a known-length segment (e.g., a pedestrian crossing).

Metric:

- Mean Absolute Error (MAE) between estimated and true speed.

Option B – Relative Speed (if calibration is too difficult)

We evaluate not the speed value, but whether the system detects unusually fast vehicles.
Ground Truth:

- Manually label 30–50 "fast" vs "normal" movements.

Metrics:

- Precision, Recall, F1 for identifying “speeding” cases.

3.2.4 Trajectory Anomaly Detection Evaluation (NEW)

We will detect anomalies such as illegal turns, U-turns, driving in pedestrian zones, etc.
Ground Truth Creation:

- For a small subset (~10 short clips), we manually label:
    - Normal trajectories
    - Anomalous trajectories
    - Pedestrians in restricted zones

Metrics:

- Precision, Recall, F1
- ROC curve (optional)

What counts as “anomaly”?

- Trajectory deviates significantly from the cluster centroid
- Wrong direction
- Entering forbidden polygon zone
- Very high speed (relative)

Since implementing advanced anomaly models is complex, we will use simple baselines:

- DBSCAN or K-means over trajectories
- Rule-based forbidden zones
- Z-score of speed for speeding detection

3.3 Summary Table of Evaluation Tasks

Task	Dataset	Method	Metrics
Detection	UA-DETRAC	YOLOv8	Precision/Recall
Tracking	UA-DETRAC	ByteTrack	MOTA, MOTP, IDF1
Lane Assignment	Manual subset	Lane polygons + matching	Accuracy, Confusion Matrix
Speed Estimation	Manual subset	Pixel displacement + homography (or relative speed)	MAE or F1
Trajectory Anomalies	Manual subset	Clustering + forbidden regions	Precision, Recall, F1