Enhancing Low-Light Traffic Monitoring at Intersections Using Event-Based Vision Systems

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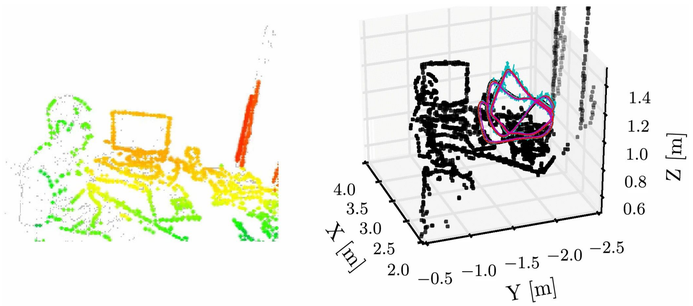
Research Question

How can event-based vision systems enhance the accuracy and efficiency of traffic participant detection and tracking at intersections in low-light and high-contrast conditions compared to traditional frame-based methods?

Background

Traditional traffic cameras operate at **fixed frame rates** and often **fail in low-light or glare-heavy scenarios**, leading to **motion blur and missed detections**.

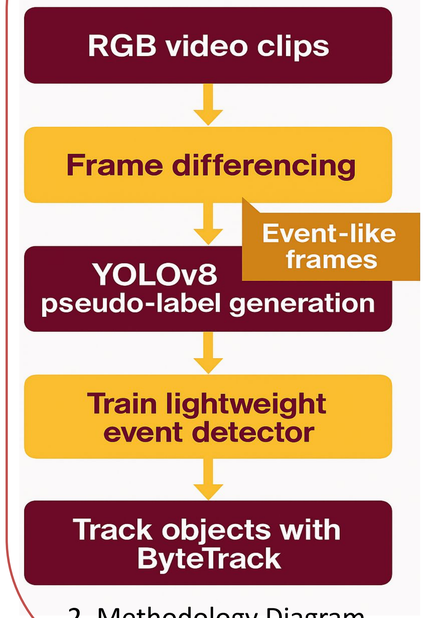
Event cameras mimic **biological vision by capturing pixel changes asynchronously**, resulting in **high temporal resolution and low latency**. Their potential remains underexplored in static traffic monitoring, especially for intersections (Neuromorphic Vision).



(a) Events & projected map. (b) Camera trajectory & 3D map.

1. Events in 4 dimensions

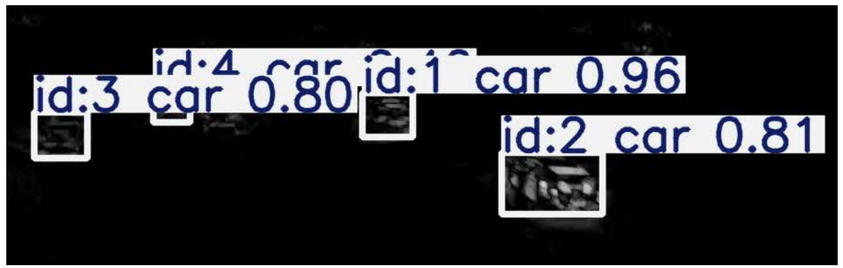
Methodology



2. Methodology Diagram

- We used nighttime traffic clips to generate **synthetic event frames** from RGB footage.
- YOLOv8n pretrained weights produced pseudo-labels, which were used to train a **event detector**.
- Object tracking was performed with **ByteTrack**, yielding per-frame bounding boxes and ID consistency across frames.

Results



3. Successful detection frame

- The event-based detector produced **stable bounding boxes** on cars even under strong headlight glare.
- The frame-based RGB pipeline failed to detect cars consistently in similar conditions.
- Quantitatively, event mAP_{50} ≈ **0.20** versus RGB baseline **0.18** on the small test set.
- The trained model was lightweight (5.4 MB) and ran at **~9 ms per frame** on a T4 GPU.
- Conducted side-by-side event vs RGB comparison

Future Plans

- Expand to **eTraM Dataset (CVPR 2024)** for real-event training under multiple lighting/weather conditions.
- Integrate **Recurrent Vision Transformers (RVT)** for long-term temporal reasoning.
- Explore **event + frame fusion models** for robust 24-hour traffic monitoring.
- Evaluate real-time deployment on embedded devices (e.g., Jetson Nano or Qualcomm Snapdragon).

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