



Evaluating Micromobility & Dangerous Riding Behaviors

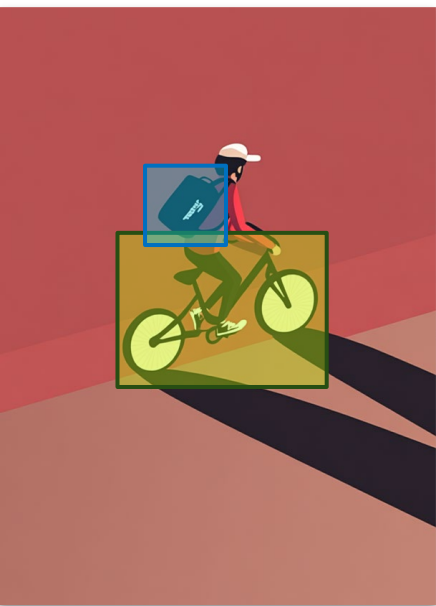
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Computer Vision & Micromobility: A Challenge

- Visual collection of traffic analytics for micromobility is a challenge:
 - Modern VLM models cannot run in <math><500\text{ms}</math>, whereas real time applications demand <math><33\text{ms}</math>,
 - Lack of annotated data,
 - Rapidly evolving visuals not captured by existing large-scale AI models



Digital Twins for Photorealistic Data Generation



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Real-World Data Collection



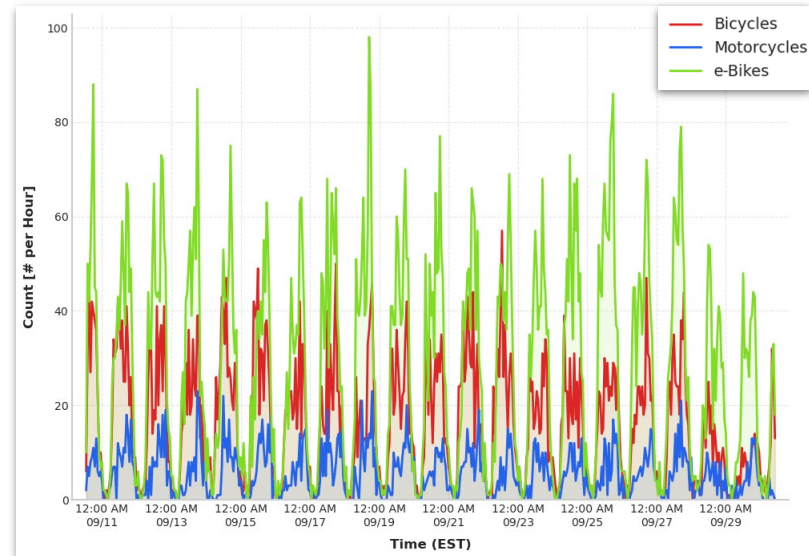
Figure: Real-time object detection and tracking for micromobility classes.



Figure: Sample plot of collected e-bike tracks in bird's-eye view.

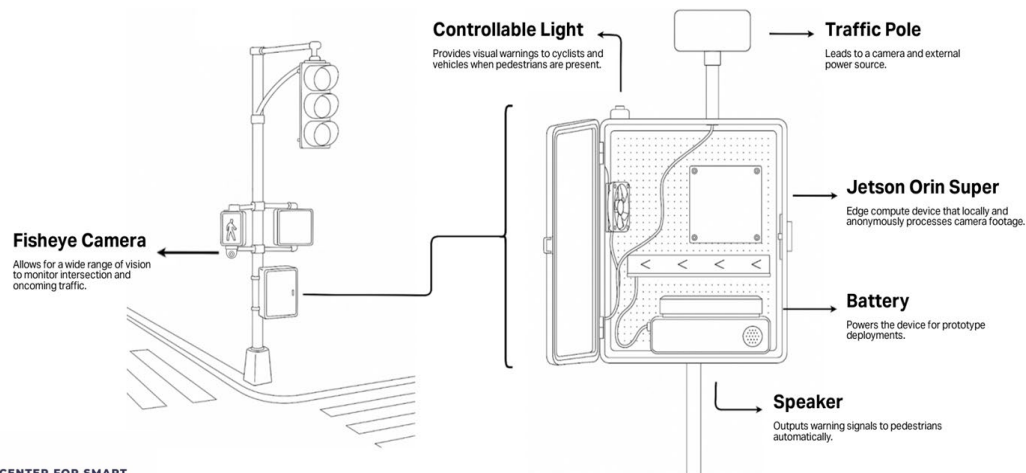
Volume of e-bike and e-micromobility devices on our streets

- Obtained by developing custom object detection models for e-bike, bicycle, motorcycle detection in real-time
 - We trained and evaluated the models in a New York City intersection, part of the COSMOS testbed
 - 14,000 frames hand-annotated for these object types
 - These models will be made available publicly

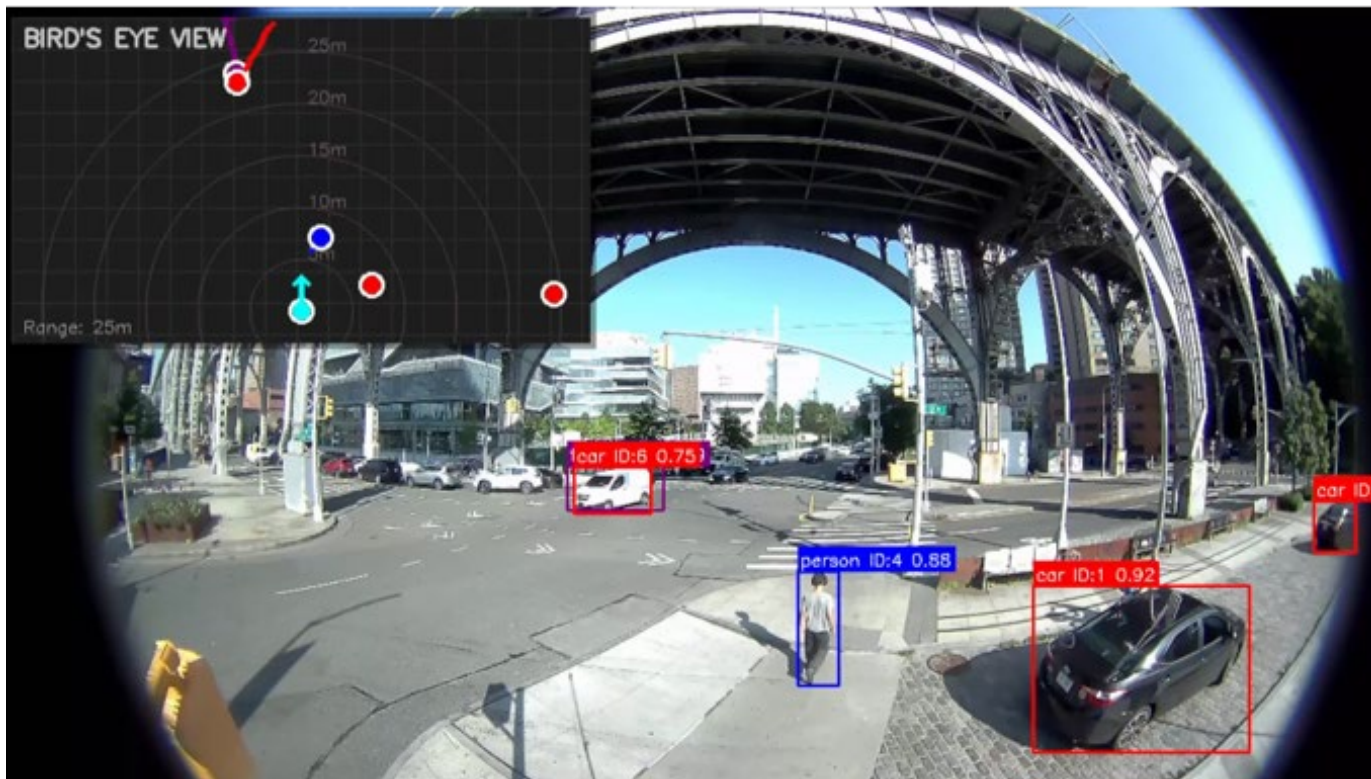


Pedestrian Notification System for Oncoming Bikes

This intersection notification system automatically detects oncoming, fast-moving micromobility devices (bikes, e-bikes, scooters, etc) traveling from either direction and provides advanced audiovisual warning signals to pedestrians attempting to cross. The system also notifies micromobility device users of waiting pedestrians. The system analyzes data locally without storing or sending data to the cloud, mitigating privacy concerns.



Pedestrian Notification System: Demo



Methodology:

- Real-time object detection and tracking with custom models adapted to micromobility object class detection from elevated high-resolution camera placements.

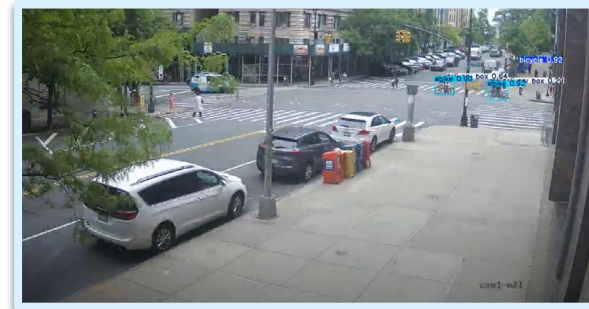
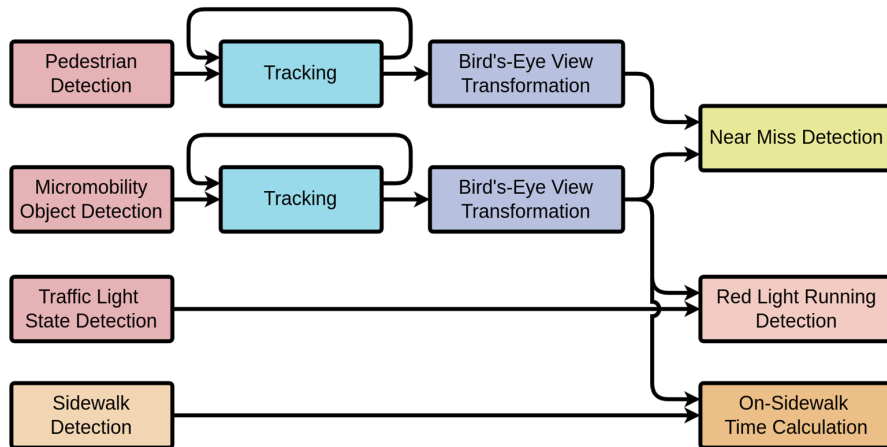


Figure: Example of automated sidewalk detection.

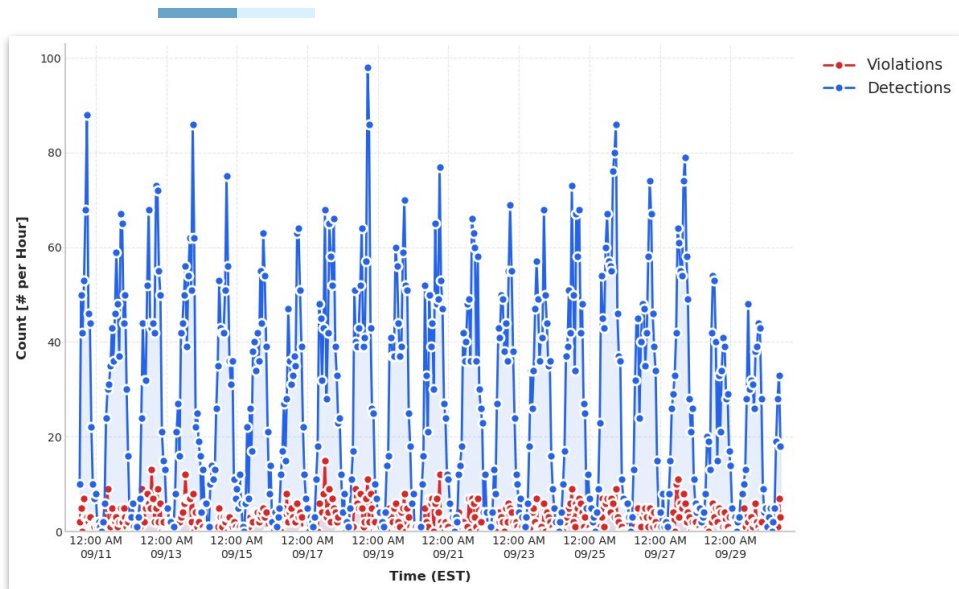


Figure: Number of e-bikes appearing on sidewalks (red), compared to total.

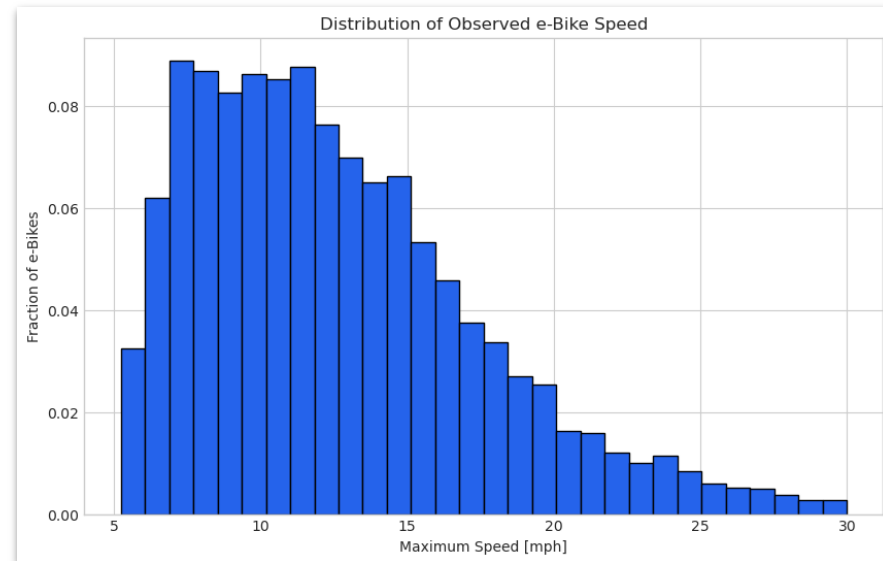
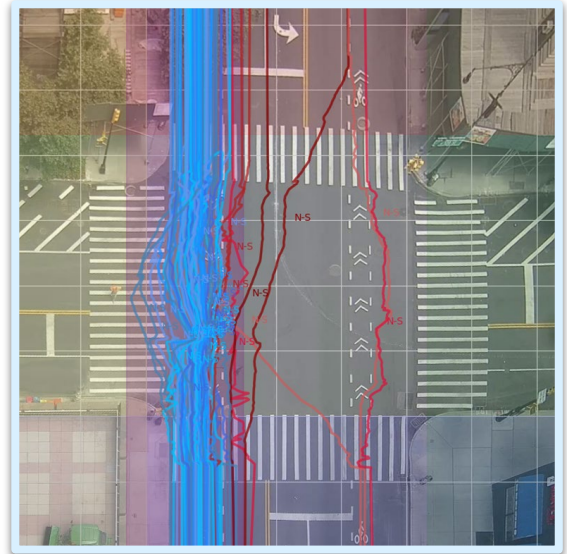
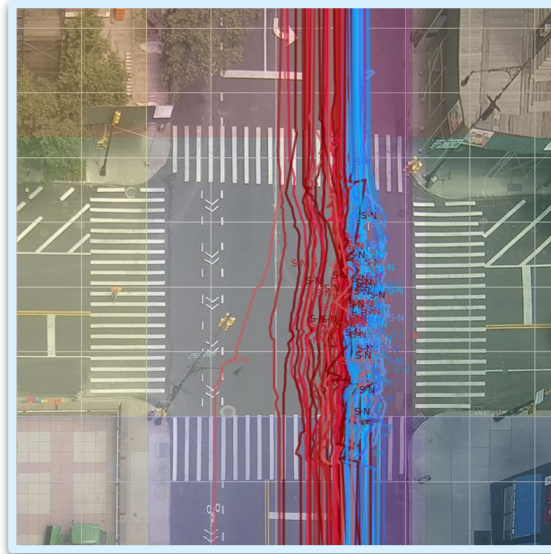
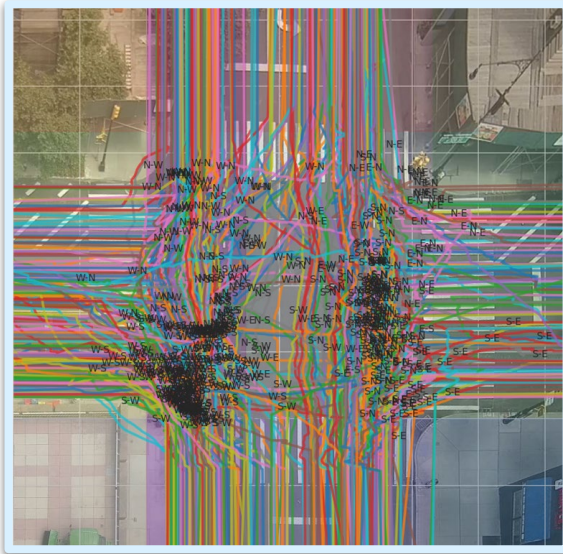
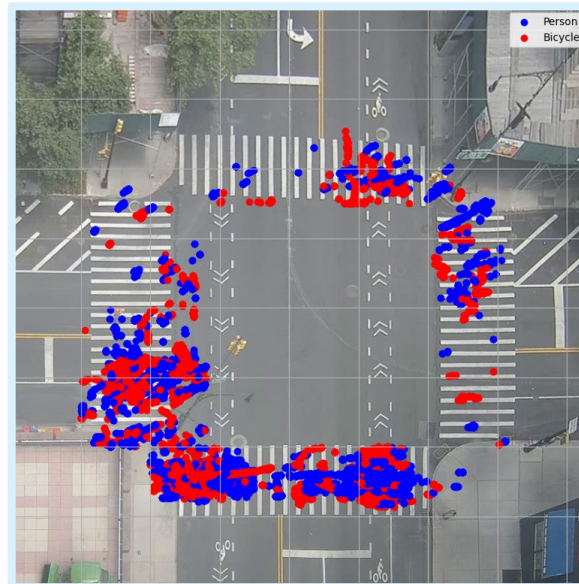


Figure: Distribution of observed e-bike speed.

Wrong-Way Riding



Near-Misses



Generalizability, Reliability, Complexity



14,000 samples to 38,000 samples
5 new intersections for data collection

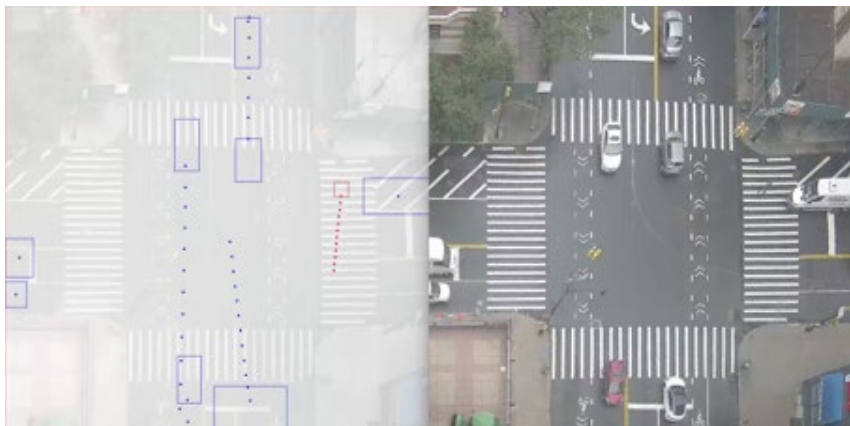
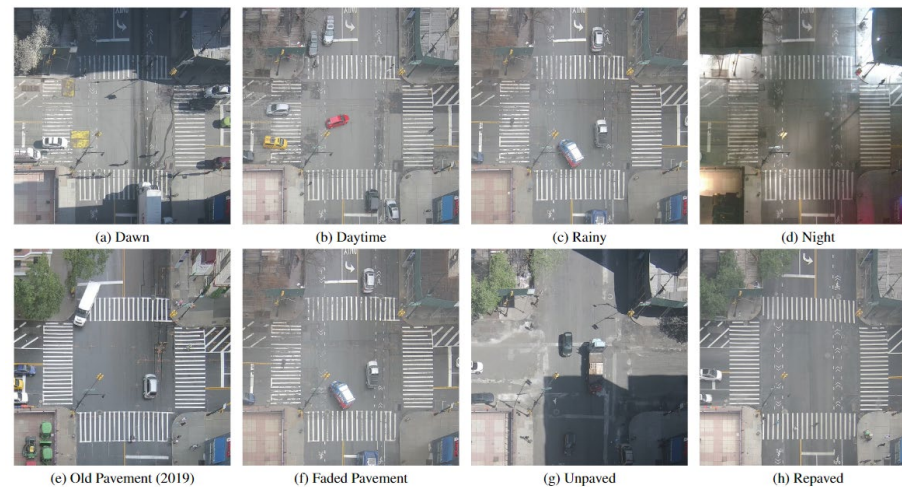


Figure: Real-time results from the high-altitude cameras.



Model Name	Pedestrian AP@0.5	Vehicle AP@0.5	mAP@0.5	Inference Time (ms)
YOLOv8x	87.4	98.6	93.0	11.5
YOLOv8n (2x)	91.2	98.5	94.8	7.2
YOLOv8x (2x)	91.2	98.4	94.8	43.6
YOLOv8n (2x+SR)	90.1	98.4	94.2	7.2
YOLOv8x (2x+SR)	91.3	98.7	95.0	43.6
YOLOv8x (P2)	89.5	98.6	94.0	15.1
YOLOv8x (P6)	89.4	98.7	94.0	7.6
YOLOv8x (P2-P6)	89.9	98.7	94.3	24.5
DETR-l	86.5	98.1	92.6	9.8
DETR-x	87.3	97.8	92.3	14.5
CFINet	82.8	95.8	89.3	31.4

Figure: Performance of the high-altitude cameras.