



FLUID: A Fine-Grained Lightweight Urban Signalized-Intersection Dataset of Dense Conflict Trajectories

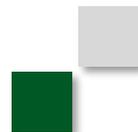
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Sep. 12th, 2025



Structure



01 INTRODUCTION

02 METHODOLOGY

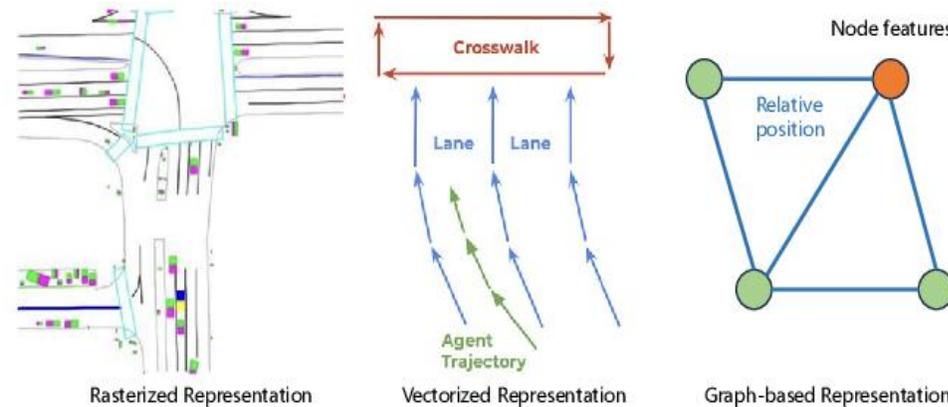
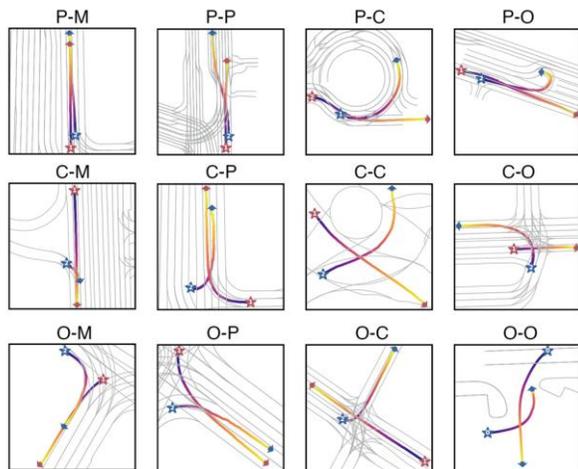
03 VALIDATION

04 RECORDS

05 FUTURE WORK

Why High-Resolution Trajectory Data is Crucial for Modern Transportation?

- Fundamental for ITS
 - Enabled by Technology
 - Critical at Intersections
- Behavioral Modeling
 - Safety Intervention
 - Autonomous Driving Test



Urban signalized intersections represent one of the most complex and hazardous environments in modern transportation systems. They are critical nodes where a diverse mix of traffic participants—including passenger cars, buses, trucks, cyclists, and pedestrians—converge, leading to intricate interactions, potential conflicts, and a high incidence of traffic accidents.

Ego-centric

KITTI

Apolloscape

Waymo

Argoverse (1/2)

nuScenes

nuPlan



- Occlusions
- A restricted field of view

Roadside

NGSIM

Zen
Traffic Data

I-24
MOTION

DLR-UT

TJRD



- Limited spatial coverage
- Potential error accumulation

Aerial

highD

exiD

CQSkyEyeX

MiTra

inD

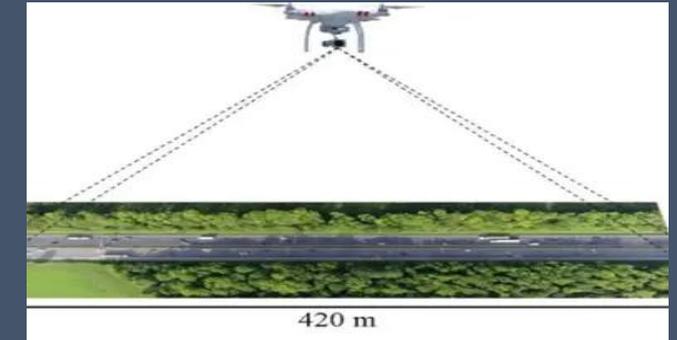
SIND

RounD

INTERACTION

pNEUMA

CitySim



- Low cost (Drone < Helicopter)
- A complete, bird's-eye view of the entire traffic scene and all simultaneous interactions within it.

NATURALESS?

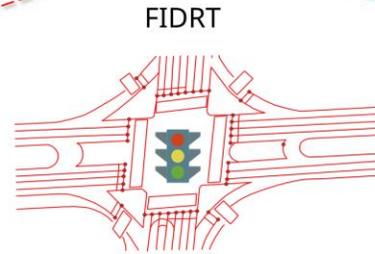
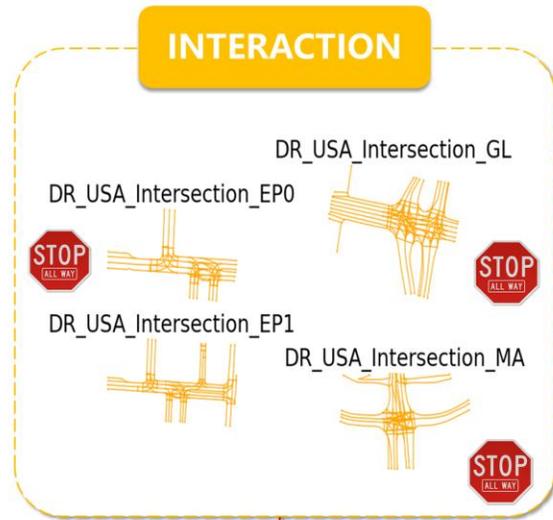
(Visible hardware can alter driver behavior)

INTRODUCTION

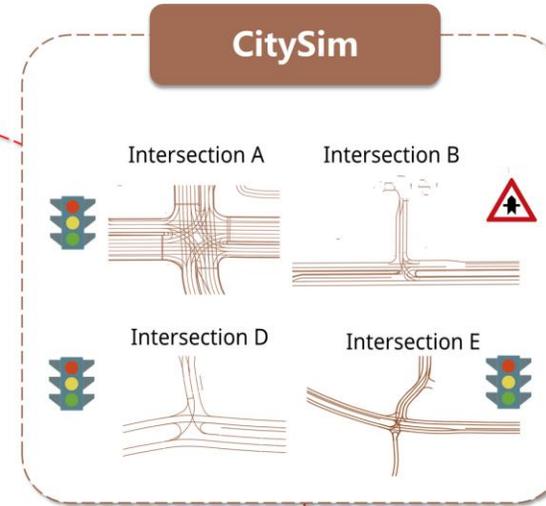
Scene Representativeness

USA
All way stop

Few TPs



FLUID

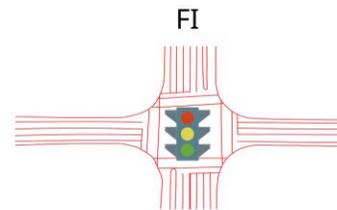
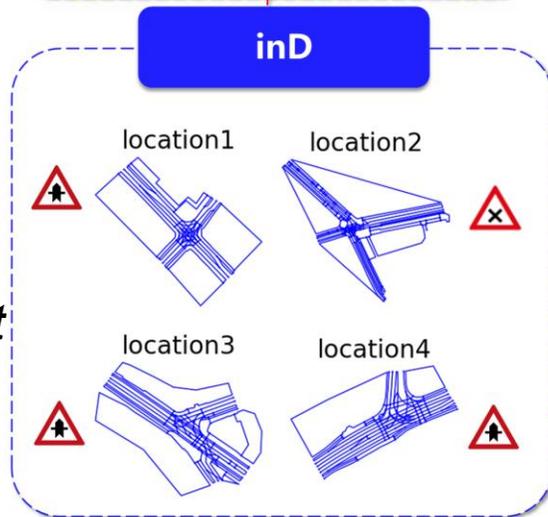


USA
Priority/Signalized

No VRUs

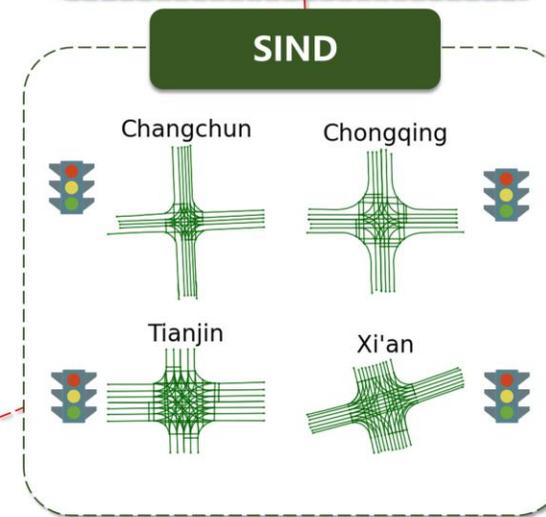
Germany
Priority/Right before left

Few TPs



TI

Xuancheng, China
Signalized
(permissive/protected)

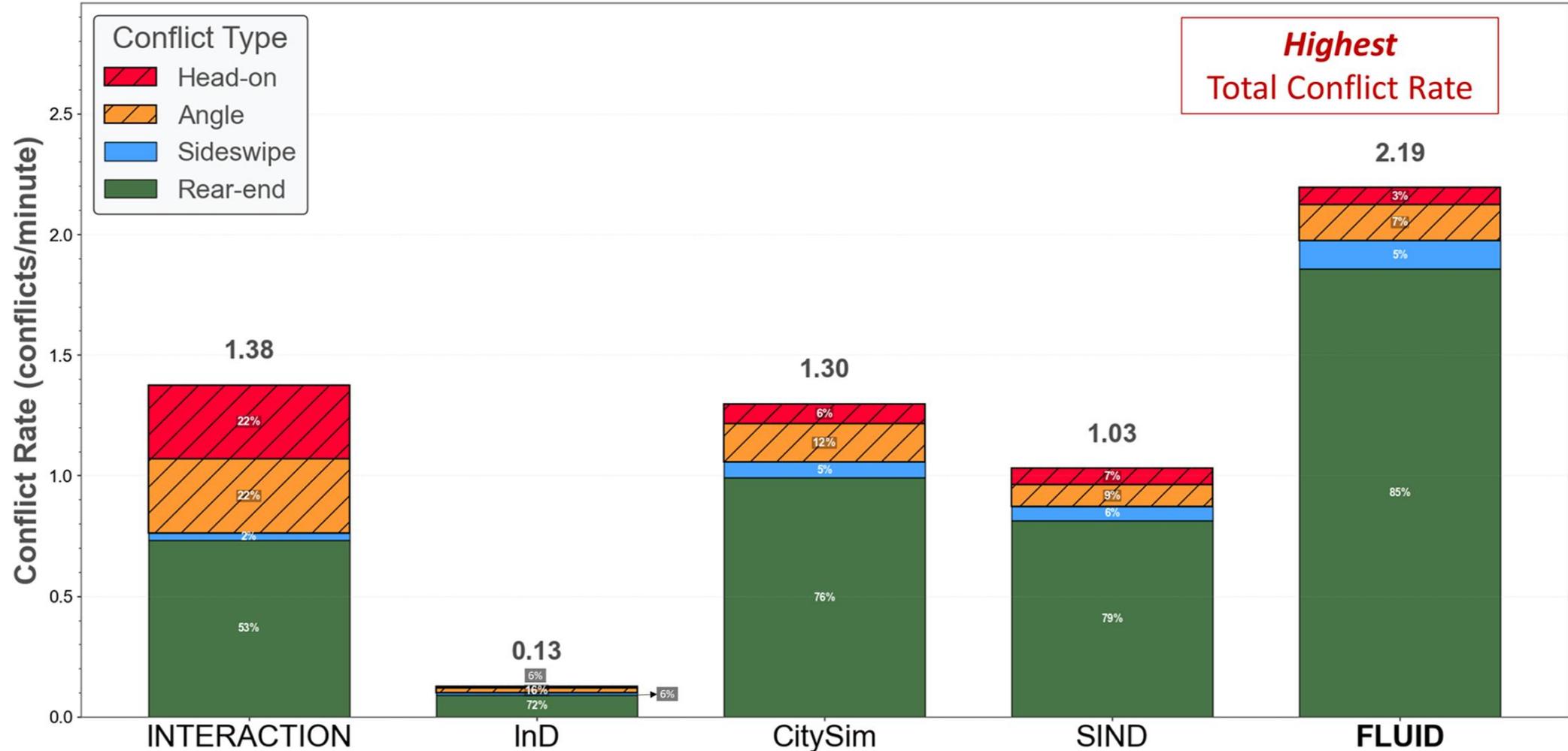


China
Signalized

Few VRUs

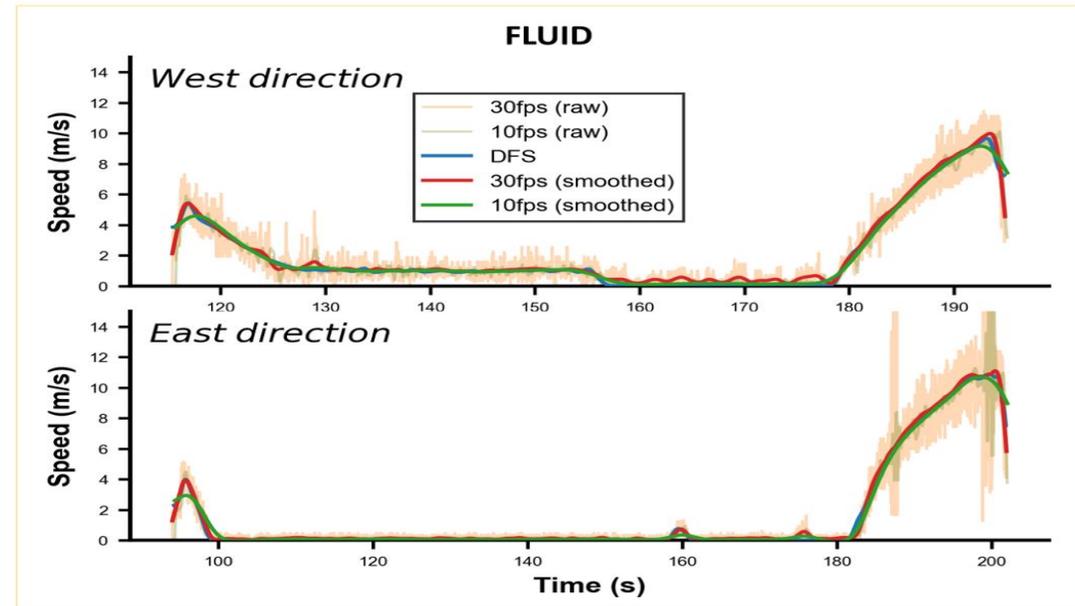
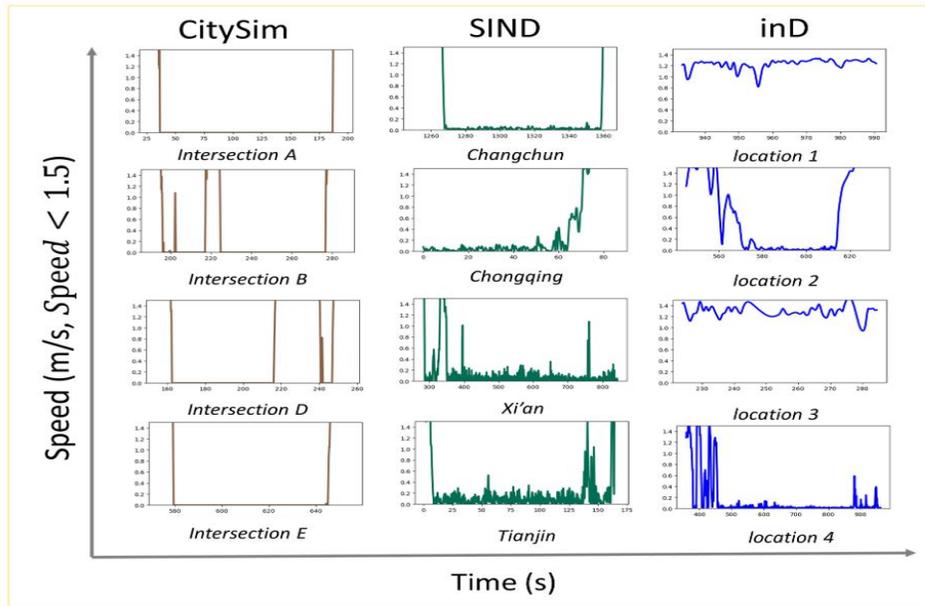
More TPs

Classify traffic Conflicts by angle



INTRODUCTION

Data Fidelity



Dataset	INTERACTION	InD	CitySim	SIND	FLUID (ours)
Scene	3	4	4	4	3
Original Results	✗	✗	✗	✗	✓
VRUs	✓	✓	✗	✓	✓
Interpolate & smooth	Manual+RTS	Manual+Bayesian+CA	Manual	Manual+RTS	Kinematic+RTS
Process frame rate (FPS)	10	25	30	10	10
Detection & Tracking	Faster R-CNN+KF	U-net+Distance matching	Mask R-CNN+CSRT	YOLOv5+IoU/KF	YOLOv8+SparseTrack

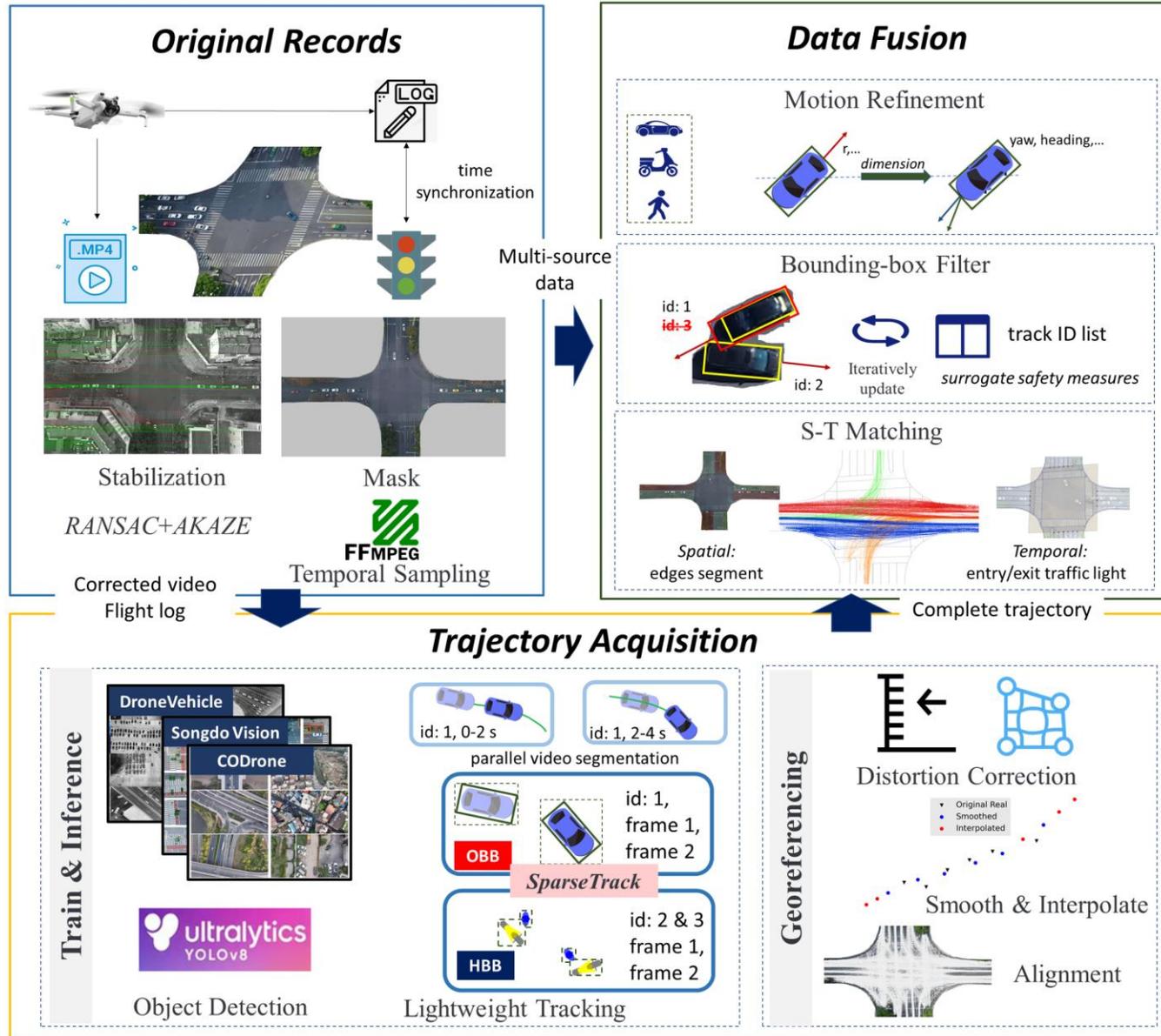
Dataset	Year	SCENE						INFORMATION				DATA QUALITY	
		Intersection Type		Traffic Flow				Object Info		Behavior Info		Validation	
		Geometries and channelization	Control methods	MV arrival rate (min^{-1})	VRU arrival rate (min^{-1})	Conflict MV ratio	Assoc. MV (≤ 10 m)	MV types	VRU types	Conflict annot.	Intention annot.	Speed	Position
INTERACTION	2019	FI, TI	U (AWS)	34	2	1.81%	0.94	car	pedestrian / bicycle	–	–	–	–
inD	2019	FI, TI	U (RBL/prio.)	13	5	5.70%	1.01	car	pedestrian, bicycle	–	–	–	–
CitySim	2022	FI, TI	S (prot./perm.) / U (prio.)	25	–	18.60%	1.43	car	–	–	–	–	–
SIND	2022	FI	S (perm.)	21	12	13.55%	1.59	car, truck, bus	pedestrian, bicycle, motorcycle	–	✓	–	–
FLUID (ours)	2025	FI, TI, FIDRT	S (prot./perm.)	30	37	24.85%	1.58	car, tricycle, van, truck, bus, trailer	pedestrian, moped	✓	✓	✓	✓

Road map

Original Records

Data Fusion

Trajectory Acquisition

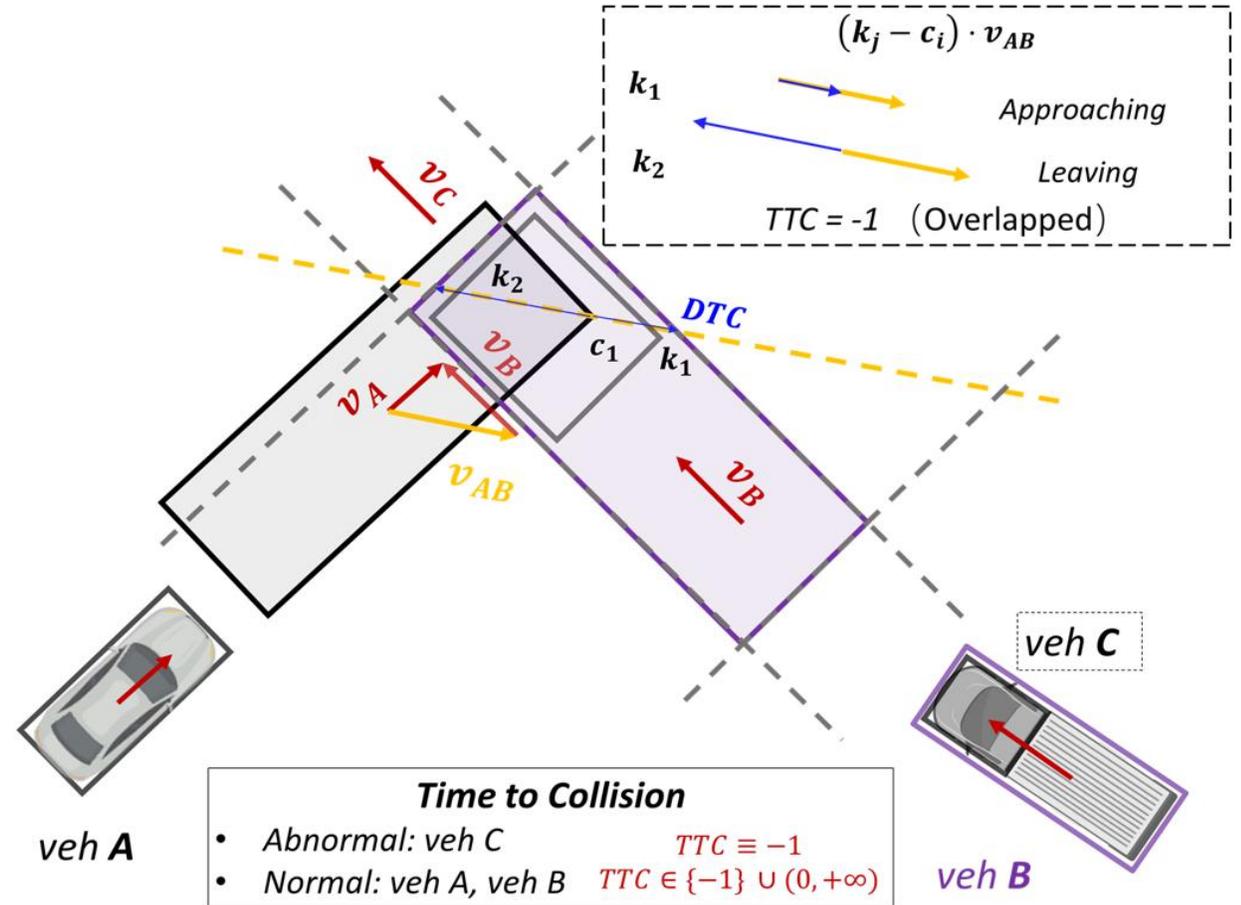
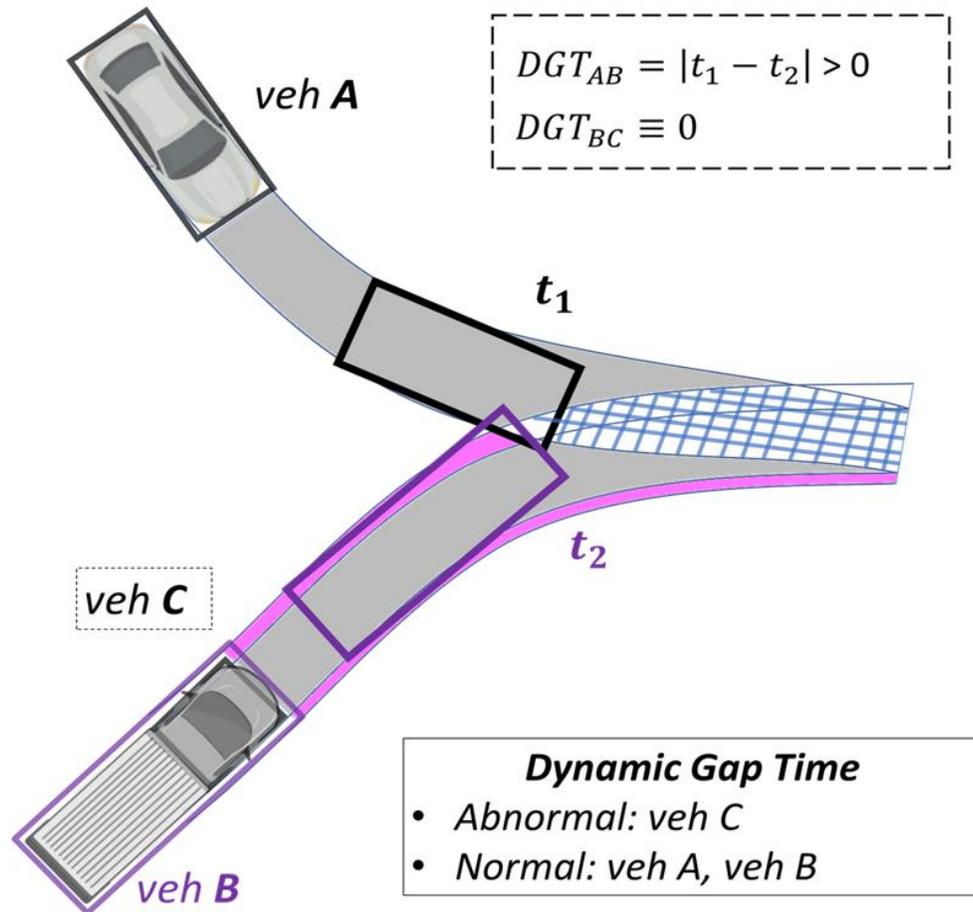


- *Detector:* YOLO v8 (OBB/HBB)
- *Tracker:* SparseTrack

- S-G Filter
- Kinematic Interpolation
- RTS Smooth

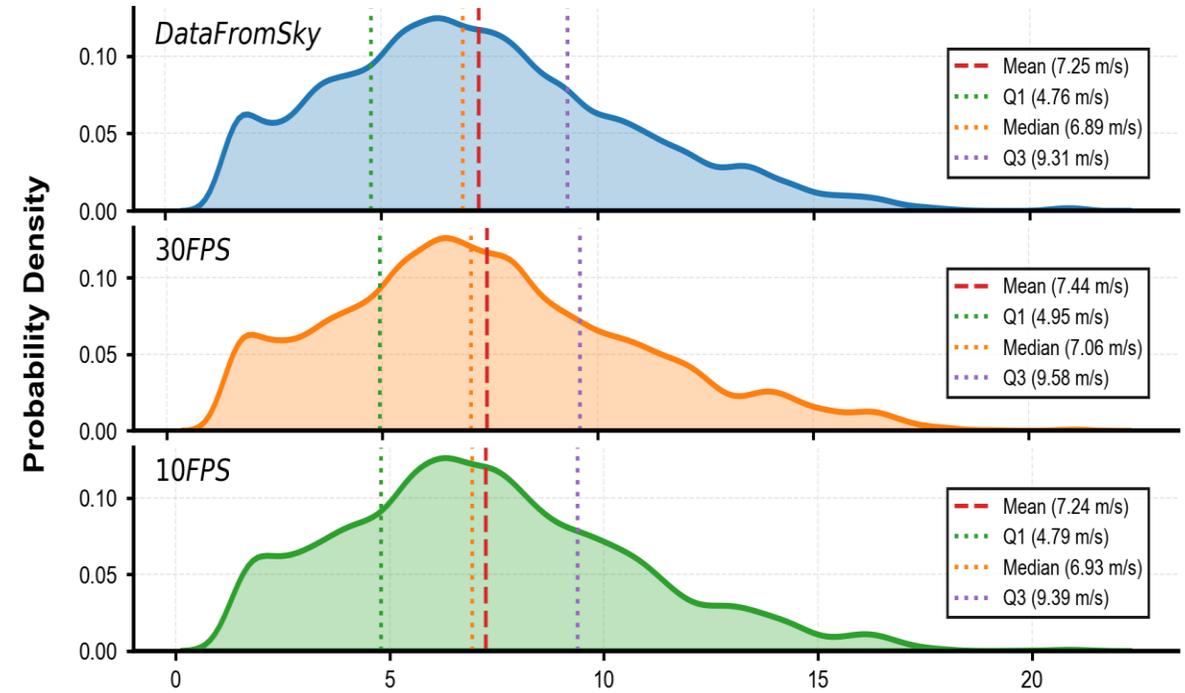
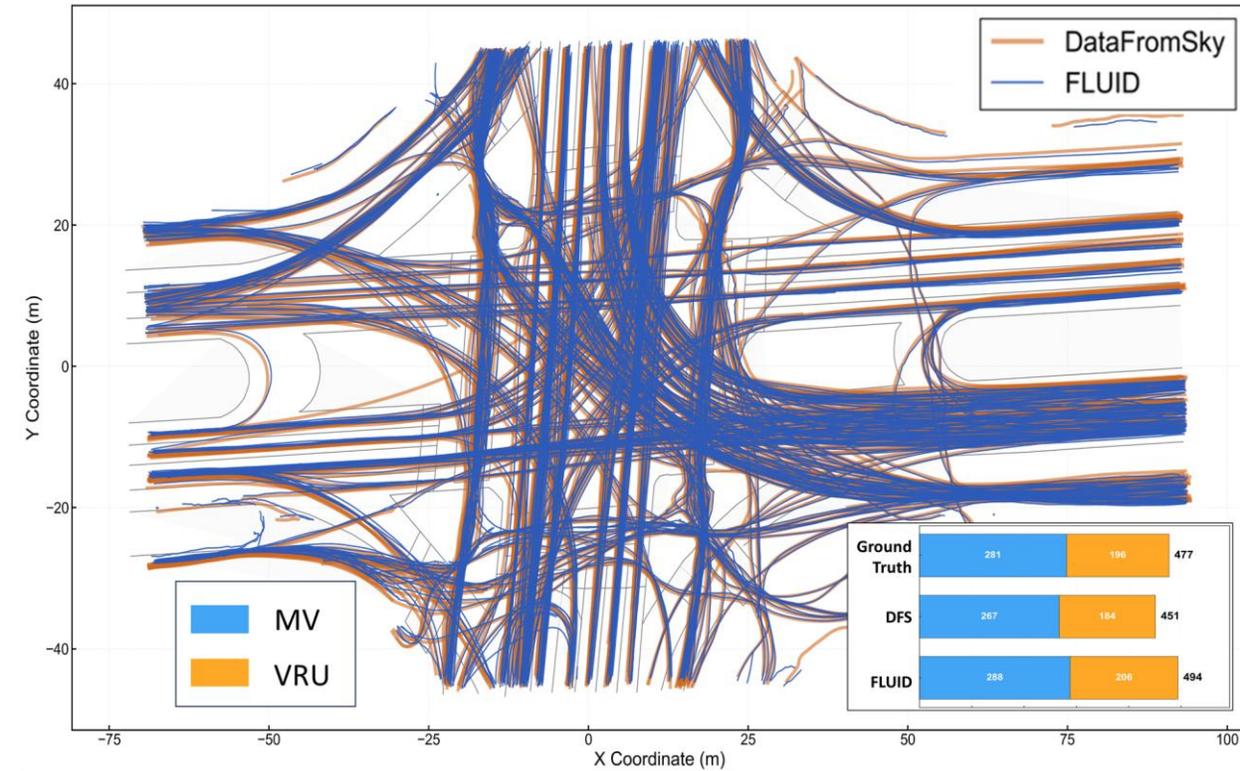
BBox Filter
(Erroneous and redundant bounding boxes)

determining potential overlaps between the bounding boxes of these two relatively moving objects.



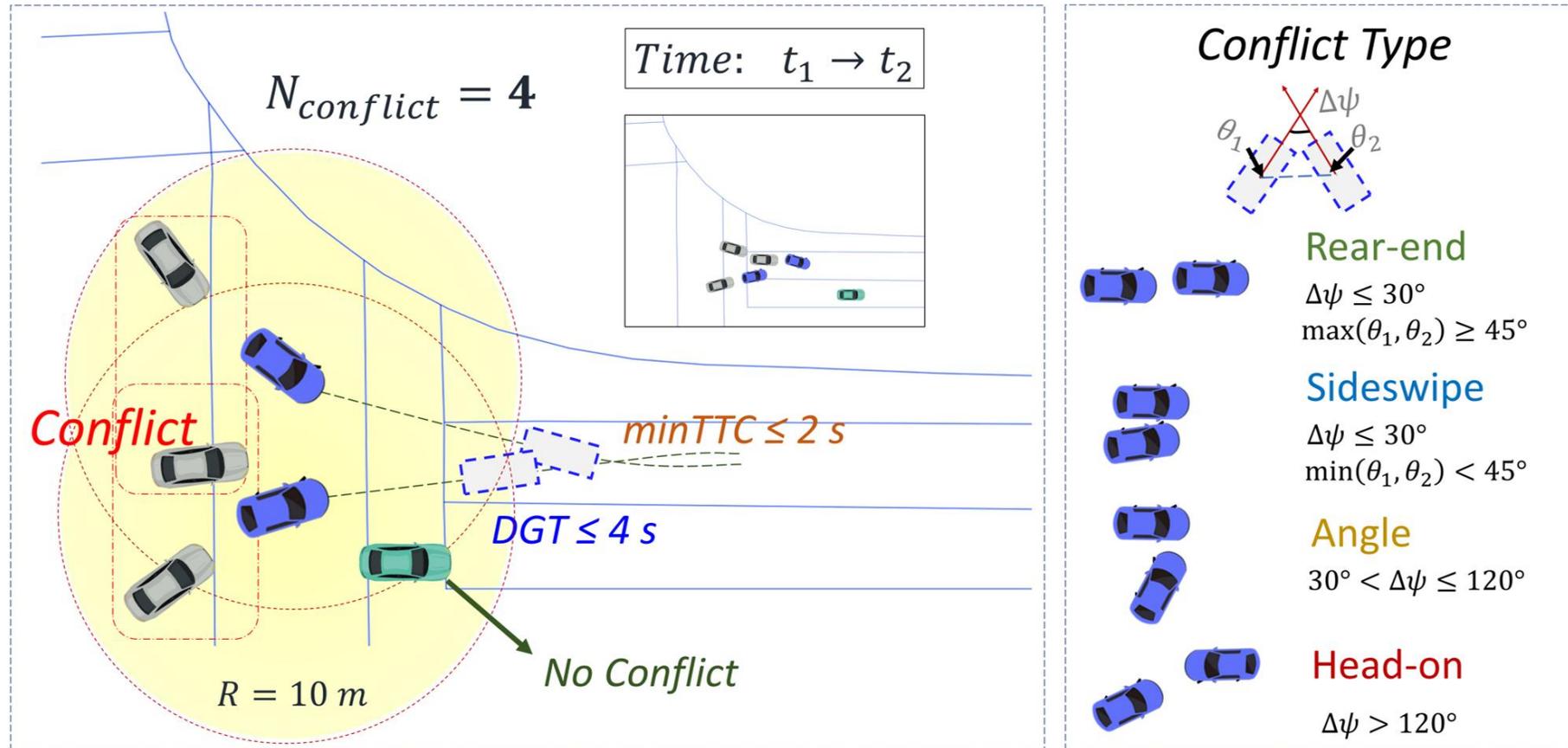
VALIDATION

Trajectory Accuracy



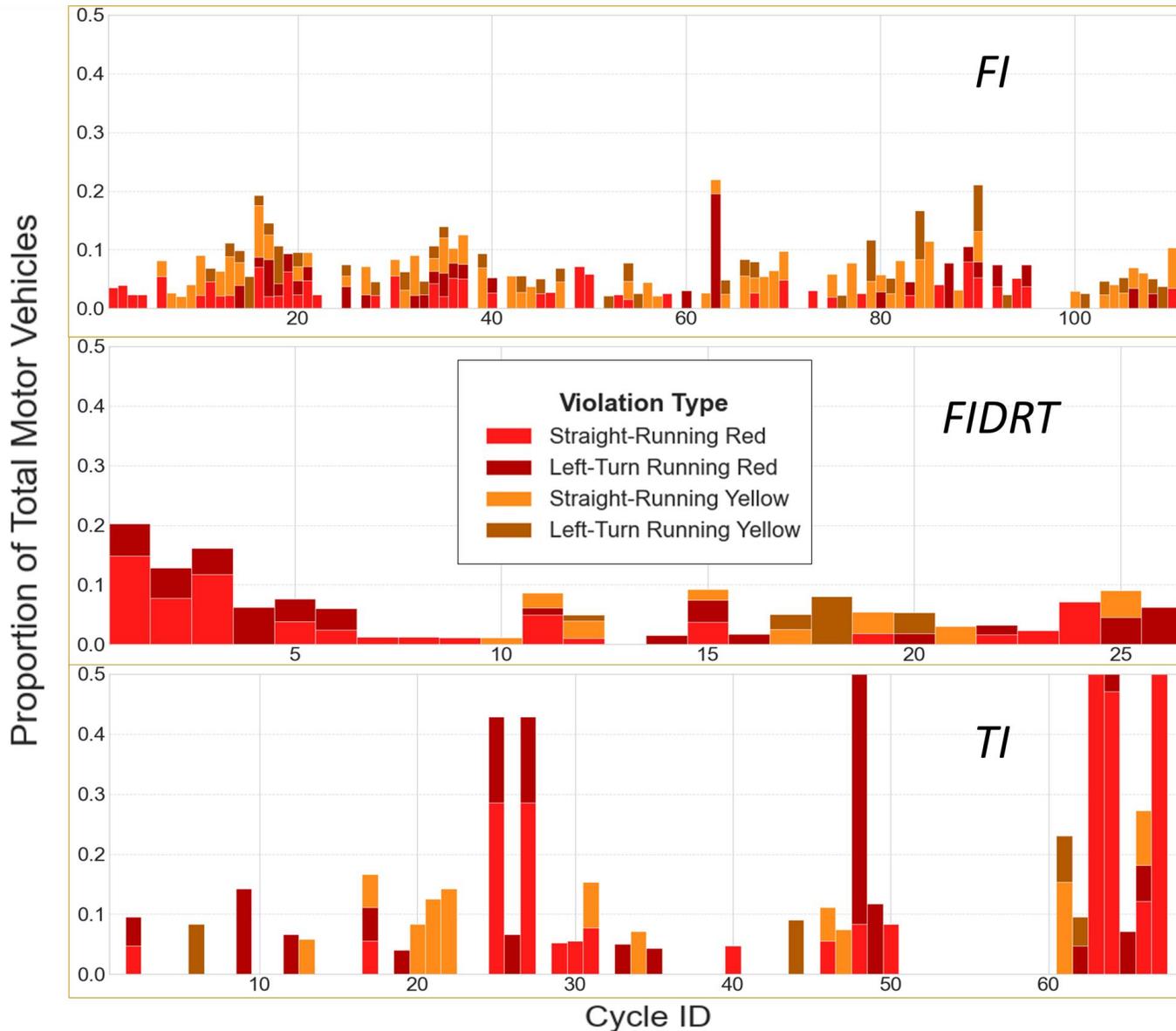
Downsample: 30 FPS → 10 FPS

No significant impact on **speed and position accuracy.**



Our analysis reveals that VRUs constitute **35.4%** of all agents within a 10-meter radius of a conflict pair in FLUID. This proportion is substantially higher than that in **SIND (7.2%)**, **inD (23.7%)**, and **INTERACTION (4.4%)**.

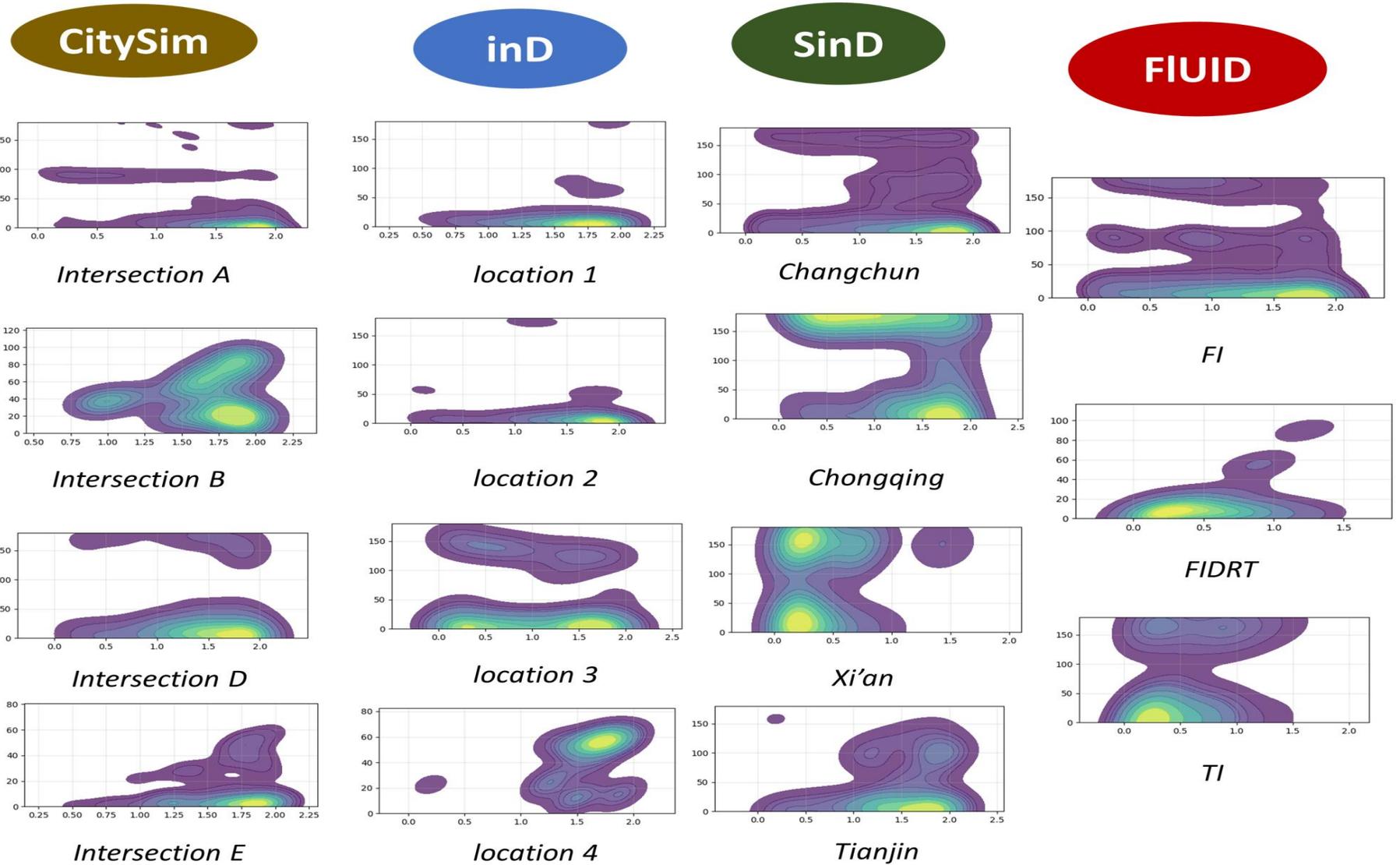
Per-cycle Violation rates

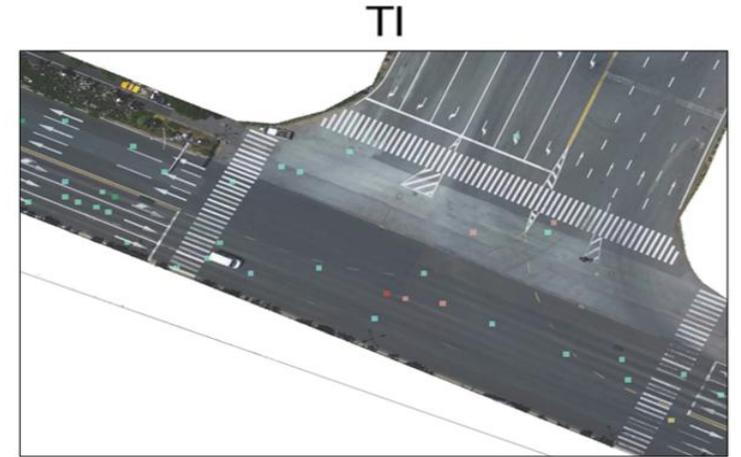
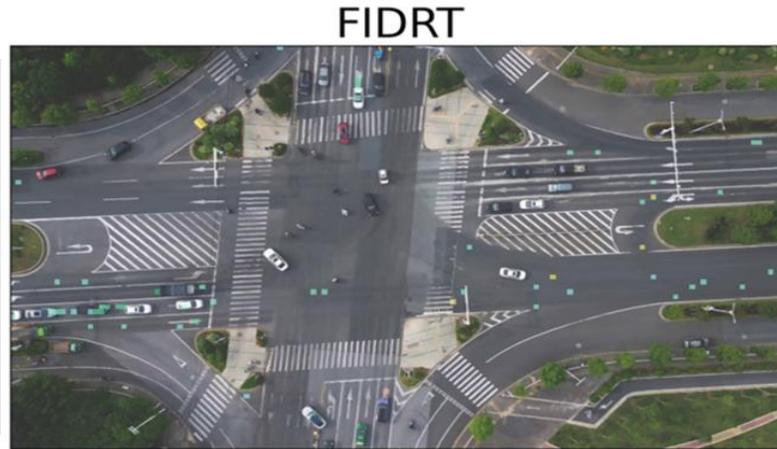
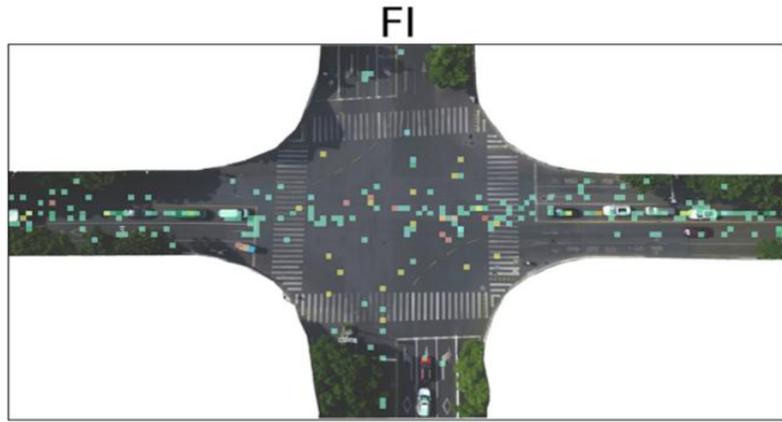


non-consecutive videos,
Cycles:
110 for FI,
26 for FIDRT,
and 68 for TI

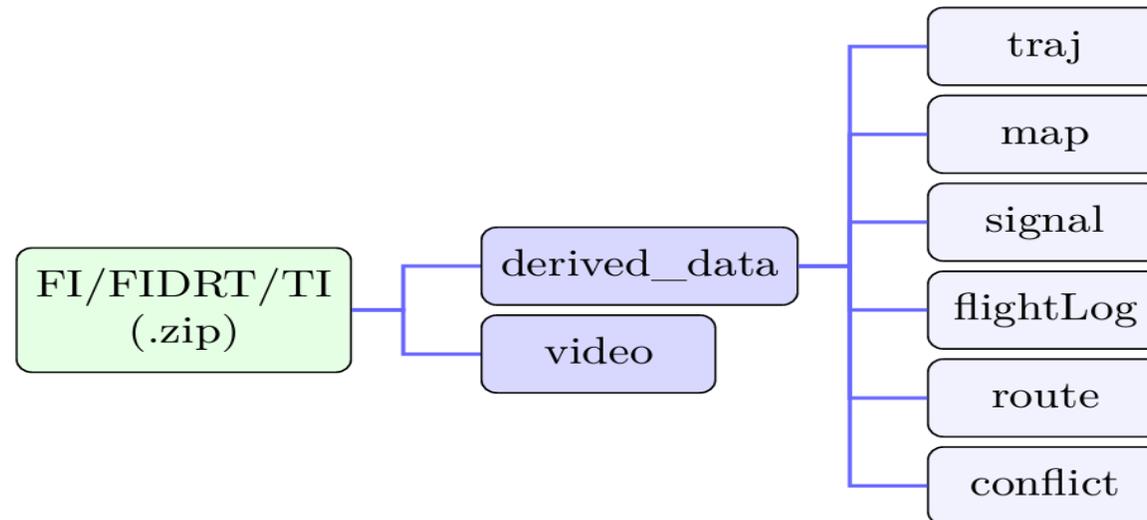
TTC (x-axis)
&
Angles (y-axis)

2D-KDE





■ Head On ■ Angle ■ Sideswipe ■ Rear End



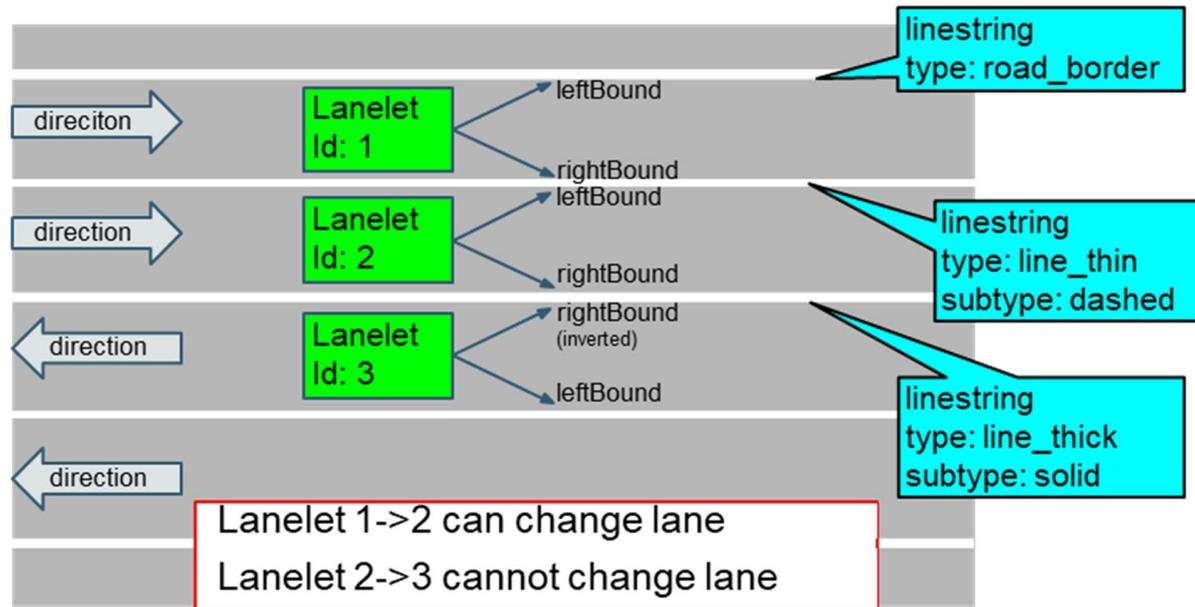
Key	Contents	Type	Example Value
type	Type of boundary	string	line_thin
subtype	type in more details	string	solid
lane_change (optional)	overrides whether it is possible to change lane or not	string	yes/no

Type and Subtype tags imply availability for lane change unless overridden by lanch_change tag.

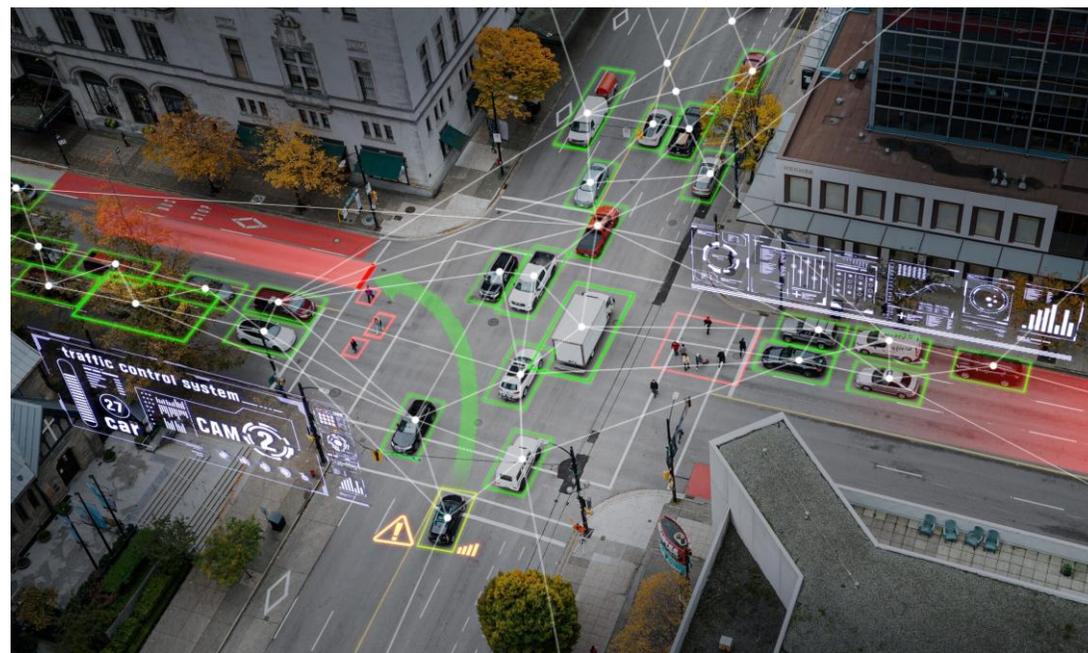
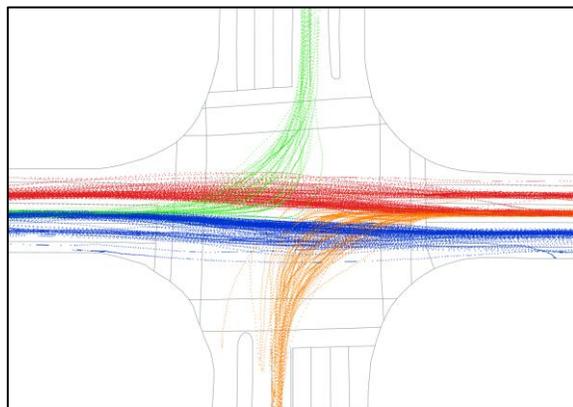
See following table

see [here](#) for more details about tags

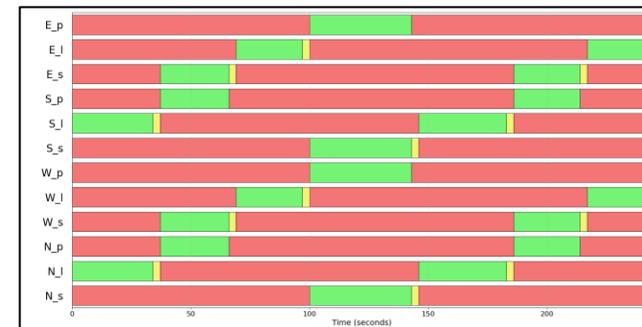
type	subtype	description	lane change?
line_thin	solid	a solid lane marking	no
line_thin	dashed	a dashed lane marking	yes
line_thin	dashed_solid	a marking that is dashed on the right and solid on the left	left->right: yes
line_thin	solid_dashed	the other way around	right->left: yes
line_thick	same as above for thin		
curbstone	high	a curbstone that is to high for a vehicle to drive over	no
curbstone	low	curb that is low and can be driven for a vehicle	no
virtual	-	a non-physical lane boundary, intended mainly for intersections	no
road_border	-	the end of the road.	no



Driving Decision Modeling



Intersection Operation Quantification



Conflict Correlation Analysis



Trajectory Generation

Main References

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14. Feng, S. et al. Dense reinforcement learning for safety validation of autonomous vehicles. *Nature* 615, 620–627 (2023)



Thanks for Listening!

A paper with the same title is available on *arXiv*.

The dataset will be public soon!