Bicycle-car and bicycle-truck turning interactions at an urban intersection

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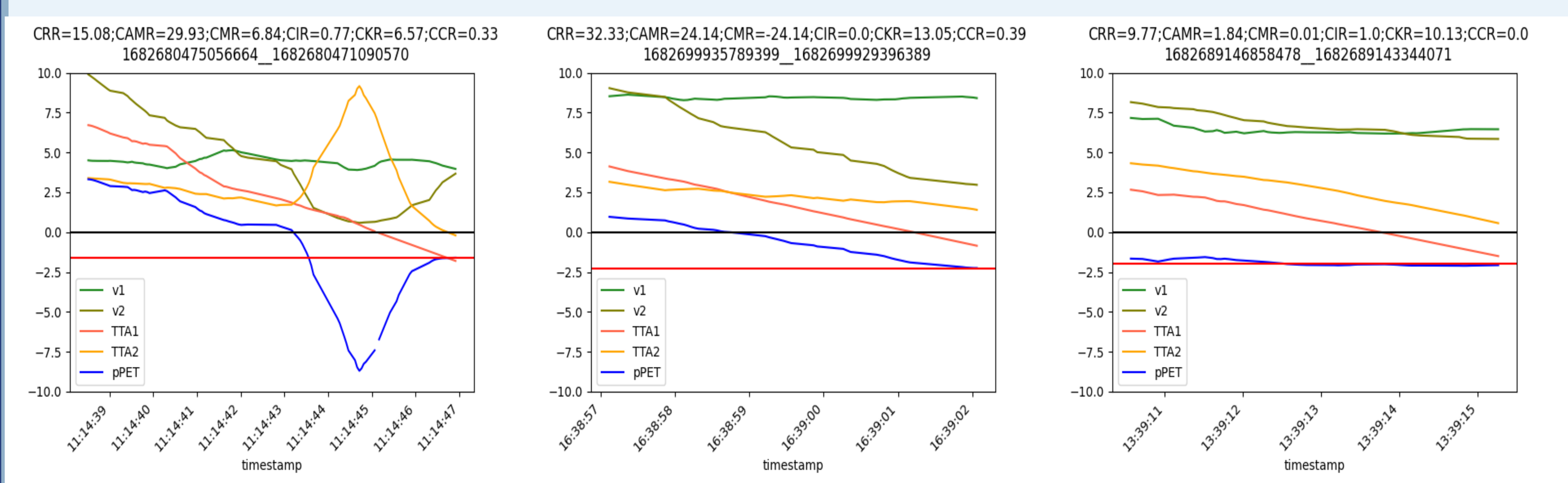
Introduction

Bicyclists were 14.6% of the road fatalities in Germany in 2019, mostly at intersections. To better understand the sources of risk for bicyclists, new SMoSs (Surrogate Measures of Safety) are developed and investigated using 196 hours of manually labelled data from the AIM Research Intersection **[1]**.

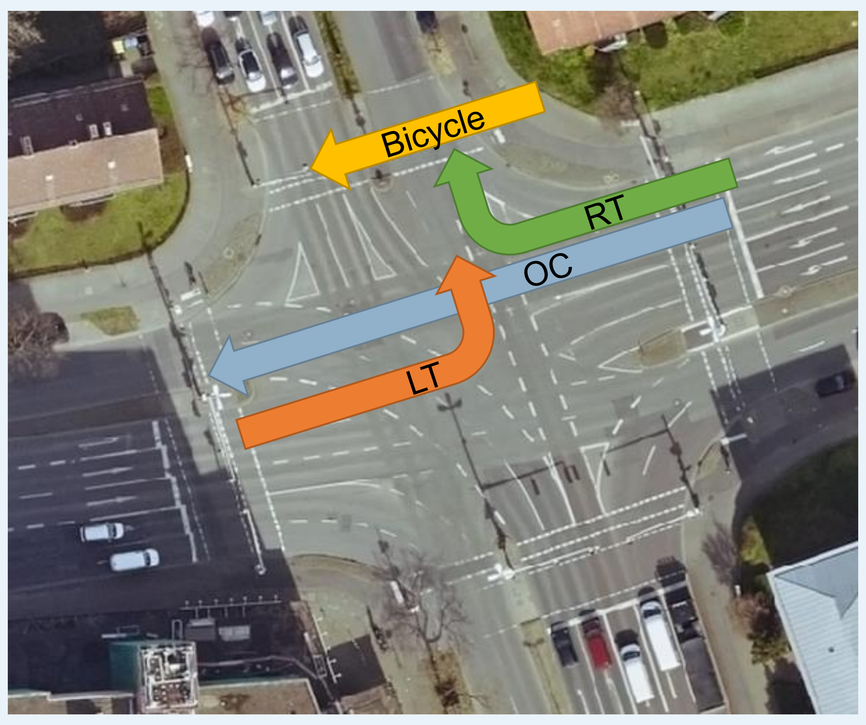
Criticality & evasive manoeuvres

- Critical situations' usual characteristics:
    - Bicycle vs LT: -1s < PET [*1] < 1.75s
    - Bicycle vs RT: -1s < PET < 2.5s
    - Car crosses first and does not brake for the bicycle!
- PET can be small but not critical due to a clearly controlled situation.
- Novel SMoSs based on the predicted PET (see yellow table) are proposed to identify critical situations & evasive manouvres considering the whole interaction.
- Here are some examples of how they work:



Situation	CRR	CAMR	CMR	CIR	CKR	CCR	Description
1 (left)	o	++	+	++	o	+	Non-critical & indecisive proactive acceleration after braking
2 (middle)	+	++	--	o	+	+	Critical & decisive evasive braking
4 (right)	oo	oo	oo		+	oo	Non-critical & neutral manouvre

Interactions & behaviour



RT: Right-turning traffic
LT: Left-turning traffic
OC: Oncoming traffic

AIM Research Intersection in Braunschweig, Germany [1]

- In LT-bicycle interactions, LT also interacts with OC, making the situation more complex
- LTs stop before bicycles cross and then accelerate again.
- RTs reduce speeds as reaction to bicycle.
- Second simultaneous LT usually accelerate to avoid the next OC.
- When multiple simultaneous RT/LT situations occur, the first one usually has a smaller PET with the bicycle to accommodate the second one.

Conclusions & future prospects

- No important differences between trucks and other types of cars.
- These SMoS are useful to detect and evaluate whole manoeuvres and characterise them.
- But: they did not perform statistically better than the PET to identify criticality.
- Investigate other metrics like: D1(T1), D1(D2_min), T2_min and DeltaV_Bicycle(D2_min) **[2]**.

Proposed SMoSs	Formula	Interpretation
Crossing Risk Ratio (CRR)	$CRR = \int_{t_i}^{t_f} \frac{1}{\lvert pPET(t)\rvert} dt$	Risk of collision
Crossing Absolute Manoeuvre Ratio (CAMR)	$CAMR = \int_{t_i}^{t_f} \lvert pPET(t) - PET\rvert dt$	Existence of a manoeuvre
Crossing Manoeuvre Ratio (CMR)	$CMR = \int_{t_i}^{t_f} pPET(t) - PET\, dt$	CMR < 0: evasive manoeuvre CMR > 0: proactive manoeuvre
Crossing Indecision Ratio (CIR)	$CIR = \frac{CAMR - \lvert CMR\rvert}{CAMR}$	Degree of indecisiveness of the manoeuvre
Crossing Kinetic Ratio (CKR)	$CKR = \frac{1}{2}\int_{t_i}^{t_f} (v_2(t)^{*2} \cdot \sin(\alpha_{crash}))^2 dt$	Potential kinetic energy of a collision
Crossing Criticality Ratio (CCR)	$CCR = \frac{1}{2}\int_{t_i}^{t_f} \frac{1}{\lvert pPET(t)\rvert} \cdot (v_2(t) \cdot \sin(\alpha_{crash}))^2 dt$	Criticality of the interaction

[1] Knake-Langhorst, S., & Gimm, K., AIM Research Intersection: Instrument for traffic detection and behavior assessment for a complex urban intersection. Journal of large-scale research facilities JLSRF, 2, A65-A65, 2016
[2] Oksana Yastremska-Kravchenko, Aliaksei Laureshyn, et al., What constitutes traffic event severity in terms of human danger perception?, 2022

*1 PET: post-encroachment time. In this case, negative value means that the car crossed first. Positive value means that the bicycle crossed first.
*2 v_2: velocity of the second crosser