How do expert and non-expert drivers interact with cyclists at unsignalized intersections? Results from naturalistic data

Ali Mohammadi, Marco Dozza

Department of Mechanics and Maritime Sciences
Chalmers University of Technology
Chalmersplatsen 4, 41296, Gothenburg, Sweden
email: ali.mohammadi@chalmers.se
email: marco.dozza@chalmers.se

Keywords: cyclists' interaction, vulnerable road users, computational models, automated vehicles.

1 INTRODUCTION

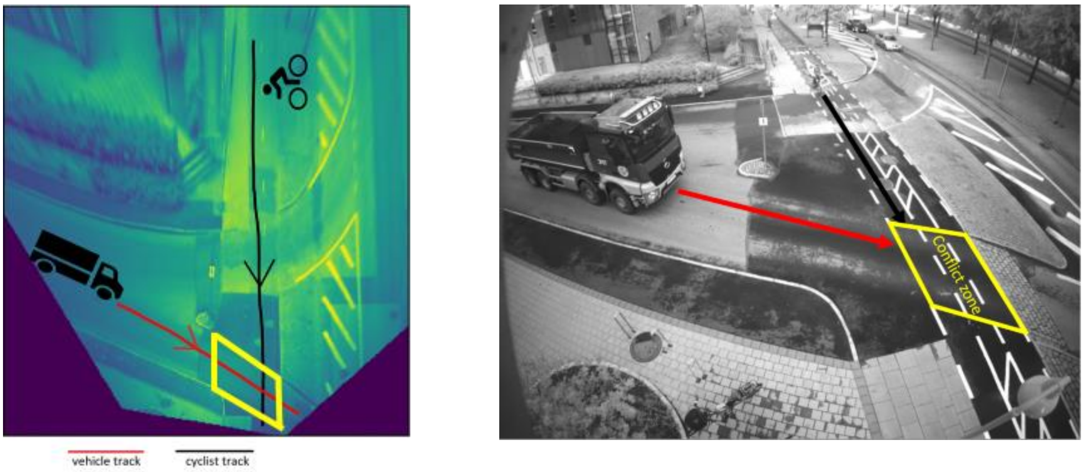
As cycling grows in popularity among European countries, it is increasingly important to understand cyclists' behavior in urban areas. This knowledge will help to develop accurate behavioral models to be used in active safety systems and automated vehicles (AVs). In fact, even as overall traffic fatalities are decreasing, the share of cyclists' fatalities is steady or increasing. Over 70% of cyclists' crashes with motorized vehicles happen at intersections, and in most cases the intersections are unsignalized and the two road users share the path [1]. By law, in Sweden motorized vehicles must give priority to cyclists and allow them to cross first at unsignalized intersections; however, in 42% of car-cyclist interactions the vehicles did not yield [1].

Few studies have quantitatively investigated the interactions between cyclists and motorized vehicles at unsignalized intersections. Of these, Silvano et al. developed a logistic model to predict the cyclists' yielding decision at an unsignalized roundabout [2]. In another study, Velasco et al. showed videos of oncoming vehicles to participants (as cyclists) wearing virtual reality headsets and asked the participants whether they would yield to the vehicle or not [3]. The authors found that two factors, the distance between the car and the bicycle and who has the right of way, most affected their decision to yield. So far, the interaction between cyclists and motorized vehicles has only been investigated for passenger cars, not trucks or taxis (which are driven by professional drivers). Previous literature has found that truck drivers demonstrate riskier behavior compared to passenger cars' drivers in urban areas, especially in interactions with cyclists [4].

In our previous study, we investigated some factors affecting cyclists' yielding decision during interactions with passenger cars. In this work, we compared how passenger cars, taxis, and heavy vehicles interact with cyclists.

2 METHODOLOGY

The data for this study were obtained at an unsignalized intersection in Gothenburg, Sweden (GPS coordinates: 57°42'31.1"N, 11°56'22.9"E). Stereovision and an AI-based sensor from Viscando [5] mounted at the corner of the intersection recorded video of the trajectories of all road users for 14 days in June 2019. Interaction events between bicycles and motorized vehicles were extracted from six days of data (from 6:00 to 18:00). An interaction event is defined as two road users sharing the road, who may try to communicate and determine each other's intent as they each attempt to follow a comfortable, safe path [6]. This definition was used to confirm the interaction events in the trajectory dataset using the videos. Figure 1.a shows an example of the vehicle and bicycle trajectories. We extracted the interaction information for all events comprising one bicycle and one motorized vehicle (with no other road users present). The bicycles' kinematic information was acquired from the trajectory dataset and enriched by adding visual information about the cyclist after watching the video. The visual information included pedaling, hand gesture, and head turn. From the trajectory dataset, we extracted possible interaction events with a DTA (difference in time to arrival at the intersection) of less than seven seconds, and then confirmed them by watching the corresponding videos. The DTA shows which road user arrives sooner at the intersection and by how much. Vehicles were categorized as passenger cars, taxis, or heavy vehicles. For each interaction event, the post-encroachment time (PET) and projected PET were calculated as surrogate measures of the safety of the interactions. Thus, the information for each interaction event consists of bicycle and vehicle kinematics, visual information, and safety indicators. The variables in the model were calculated before the decision point, the point at which cyclists decided whether to cross the intersection first (8m before the intersection points of trajectories).



(a) (b)

Figure 1- Studied intersection: a) layout of the intersection, b) intersection view from the mounted VISCANDO sensor. The yellow box represents the conflict zone

3 RESULTS

In total, 153 interaction events between bicycles and motorized vehicles were selected: 113 with passenger cars, 16 with heavy vehicles, and 24 with taxis. In 60% of cases, cyclists crossed the intersection first; 36% of cyclists were women. Descriptive statistics of the numeric variables are shown in Table 1.

Table 1- Descriptive statistics of numeric variables

Numeric variables	Bike initial speed (m/s)	Vehicle initial speed (m/s)	DTA (s)	PET (s)	Projected PET (s)
Mean	3.98	3.38	1.83	2.6	4.06
STD	1.06	1.25	2.22	1.04	2.47
Min	0.42	0.26	-2.92	0.89	0.68
Max	7.58	8.52	8.83	6.8	12.5

Interaction events were compared based on vehicle type; the results are depicted in Figure 2. The mean PET value is 2.6 s, 3.47 s, and 2.57 s for passenger cars, heavy vehicles, and taxis, respectively.

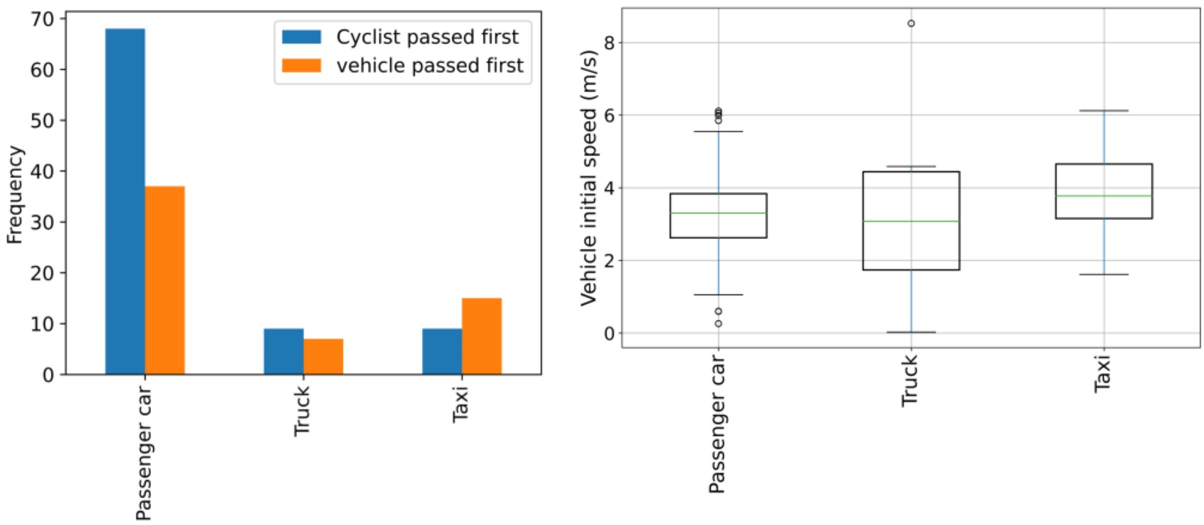


Figure 2- Summary statistics of yielding cases (a), and initial speed (when the two interacting road users see each other) for each vehicle type (b)

4 DISCUSSION

Based on the preliminary analysis of the interaction events, cyclists yielded more often to heavy vehicles and taxis than to passenger cars. This can be attributed to the riskier behavior of professional drivers. Taxi drivers had higher approaching speeds and lower PET values than the other groups. Full results will be presented at the conference and included in our paper. Our models will include: 1) the cyclist's yielding decision based on the significant variables and 2) a comparison of different modeling approaches for predicting the cyclist's decision to yield.

REFERENCES

[1] I. Isaksson-Hellman and J. Werneke, "Detailed description of bicycle and passenger car collisions based on insurance claims," *Saf. Sci.*, vol. 92, pp. 330–337, 2017, doi: 10.1016/j.ssci.2016.02.008.

[2] A. P. Silvano, H. N. Koutsopoulos, and X. Ma, "Analysis of vehicle-bicycle interactions at unsignalized crossings: A probabilistic approach and application," *Accid. Anal. Prev.*, vol. 97, pp. 38–48, 2016, doi: 10.1016/j.aap.2016.08.016.

[3] J. P. N. Velasco, A. de Vries, H. Farah, B. van Arem, and M. P. Hagenzieker, "Cyclists' crossing intentions when interacting with automated vehicles: A virtual reality study," *Inf.*, vol. 12, no. 1, pp. 1–15, 2021, doi: 10.3390/info12010007.

[4] C. Llorca, A. Angel-Domenech, F. Agustin-Gomez, and A. Garcia, "Motor vehicles overtaking cyclists on two-lane rural roads: Analysis on speed and lateral clearance," *Saf. Sci.*, vol. 92, pp. 302–310, 2015, doi: 10.1016/j.ssci.2015.11.005.

[5] "VISCANDO," [Online]. Available: https://viscando.com/.

[6] P. Thalya, J. Kovaceva, A. Knauss, N. Lubbe, and M. Dozza, "Modeling driver behavior in interactions with other road users," *Proc. 8th Transp. Res. Arena TRA 2020, April 27-30, 2020, Helsinki, Finl.*, pp. 1–16, 2020.