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MULTICHANNEL CYCLIST QUEUING BEHAVIOUR AT SIGNALISED CYCLE CROSSINGS

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Introduction

We observed cyclist queuing behaviour at signalised cycle crossings. We examined how they spontaneously form queues of various number of channels and physical length. We analyzed how the queue dissipates, showing that clearance times is strongly related with the queue formation process. We mapped cyclists' trajectories on the space-time diagram to illustrate observed phenomena. Key findings from 50 queues observed in Kraków are: 1) physical length of five-cyclists queue vary from 7m for one channel to 2.5m for three channels 2) its clearance time drops from 16s for one channel to 11s for three channels 3) number of formed channels grows with number of queuing cyclists 4) cyclists minimizing their queuing time by forming multiple channels improve the overall crossing efficiency.

This research contributes towards a developing stream of research on bicycle traffic flow. Increasing popularity of cycling, especially in modern-day urban areas, reinforce the need for in-depth understanding of bicycle traffic flow and cyclist behaviour, which is necessary to formulate an adequate approach towards the design of cycling infrastructure and traffic control systems.

Motivation

Literature review shows that despite significant advancements in fields of bicycle traffic research over the recent years, the bicycle traffic flow theory remains much less developed than the car traffic flow theory (Portilla et al., 2016). Moreover, despite the similarities in their elementary characteristics (e.g. queue forming process, reaction times, acceleration rates) the bicycle flow is substantially different and its dynamics cannot be properly explained with the classical car flow theory (Liang et al., 2012). Research sources (Twaddle et al., 2014) argue that cyclist's dynamics are characterised by a considerable degree of complexity, being less constrained by the in-situ traffic flow organisation or driving regulations, but instead more related to the individual behaviour and issues such as cyclist's stamina ("muscle strength"), which in the end amount to substantially different driving discipline and road space utilisation. Cycle traffic exhibits much greater lateral movement flexibility which can be especially observed at intersections and cycle crossings – where they do not follow one another in a single-file manner, but instead arrive often parallel and form (or "self-create") multiple channels before the stop line. This has profound implications for the estimated capacity of cycle crossings (Zhou et al., 2015) which has to take into account the parameters such as the growth rate of bicycle queue length, lateral spacing, start-up loss times and headways between consecutive cyclists. Although those values have been repeatedly empirically observed (e.g. (Raksuntorn, Khan, 2003)), the state-of-the-art studies remain a bit vague about the evolution process of the cyclist queue itself, especially the probabilistic emergence of multiple-channel arrival pattern and merging of bicycle platoons after the stop line.

Contribution

In this paper we investigate the arising cyclist queuing behaviour based on field data collected from a signalised cycle crossing at an urban intersection in the city of Krakow (Poland). The 3-metre wide cycle crossing is located along a busy, bi-directional cycle track, where we are able to observe the spontaneous emergence of various cyclist queuing (and merging) patterns. Since there is no fixed lane discipline, cyclist often form multiple channels of different lengths and overtake each other; interestingly, we observe that this "self-organisation" of bicycle flows helps to improve the queue efficiency both in spatial (i.e. by reducing the max. length) and temporal dimension (i.e. by reducing total queue clearance time). We observe their

longitudinal and lateral positions and how they spontaneously form queues of different numbers of channels and various physical lengths, and focus on the characteristic points (arrival, reaction and evacuation time), for which we derive the space-time analysis of cyclists' trajectories. Based on these, a detailed examination of queue dissipation rates reveals that clearance times are strongly related to the queue formation process.

Selected findings from our study include the following:

- non-linear correlation between the longitudinal and lateral cyclist queue dimension: the total physical length of a five-cyclist queue may vary from 2.5m (for three channels) to 7.0m (for a single channel),
- impact on queue clearance time: reduction from 16 secs (for a single channel) to 11 secs (for three channels) for queue of five cyclists,
- expected number of formed channels grows with the number of queuing cyclists,
- by forming multiple channels, cyclists contribute towards minimisation of the queuing time and thus an overall improvement of the crossing efficiency (capacity).

Though owing to a limited sample size (ca. 160 cyclists in 50 queues) we are unable to provide statistically solid conclusions, nevertheless we are able to reveal important phenomena of cyclists' queue emergence process. We formulate recommendations for follow-up works which could then reinforce our findings with statistical significance. Our objective is to contribute towards the novel bicycle flow theory, indications for signal control strategies and guidelines for efficient design of signalised cycle crossings.

References:

Liang, X., Baohua, M.A.O. and Qi, X.U., 2012. Psychological-physical force model for bicycle dynamics. Journal of Transportation Systems Engineering and Information Technology, 12(2), pp.91-97.

Portilla, C, Valencia, F, Espinosa, J, Nunez Vicencio, A & De Schutter, B 2016, 'Model-based predictive control for bicycling in urban intersections' Transportation Research. Part C: Emerging Technologies, vol 70, pp. 27-41.

Raksuntorn, W. and Khan, S., 2003. Saturation flow rate, start-up lost time, and capacity for bicycles at signalized intersections. Transportation Research Record: Journal of the TRB, (1852), pp.105-113.

Taylor, D. and Davis, W., 1999. Review of basic research in bicycle traffic science, traffic operations, and facility design. Transportation Research Record: Journal of the TRB, (1674), pp.102-110.

Twaddle, H., Schendzielorz, T. and Fakler, O., 2014. Bicycles in urban areas: Review of existing methods for modeling behavior. Transportation Research Record: Journal of the TRB, (2434), pp.140-146.

Zhou, D., Xu, C., Wang, D. and Jin, S., 2015, January. Estimating capacity of bicycle path on urban roads in Hangzhou, China. In Proceedings of the 94th Annual Meeting of the TRB.

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