SYNOPSIS

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Degree for which submitted: PhD

Department: Civil Engineering

Thesis title: Modelling Gap Acceptance Behaviour Allowing for Perceptual Distortions

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Month and year of thesis submission: March, 2026

Gap acceptance is a fundamental driving behaviour in which a driver who wants to cross or merge into another traffic stream[1] looks for gaps and decides whether to accept or reject them. Understanding and realistically modelling the gap acceptance behaviour is essential for analysing and designing traffic facilities such as unsignalized intersections, roundabouts, merging sections, auxiliary lanes, etc. Gap acceptance models also form an integral component of microscopic traffic simulation tools. The primary objective of this thesis is to understand driver behaviour during the gap acceptance process and to present a realistic modelling structure for it. In this light, an attempt was made to delve deeper into the driver's decision-making process.

Traditional gap acceptance models assume the existence of a threshold (known as the critical gap) which determines whether a gap is accepted or rejected. However, existing approaches rely on observed gaps and do not explicitly distinguish between observed gaps

[1] Henceforth referred to as the opposing traffic stream.

and the driver's perceived gaps. In reality, the acceptance or rejection of a gap results from the decision-making that happens in the person's mind and is based on the driver's perception of the gap rather than its observed value.

Accordingly, in this study, both the perceived gap and critical gap are assumed to exist in the driver's mind — a latent world. A modelling structure is proposed that distinguishes between the observed world and the latent world, acknowledging that drivers respond to perceived rather than measured conditions of the observable world.

Studies in psychophysics suggest that during perception, time durations undergo perceptual distortions that include systematic bias as well as a random component. The observed gaps, which are durations of time, also go through similar perceptual distortions during the perception process. In addition to variability in perception, variability in gap acceptance behaviour arises from multiple other sources, such as (i) systematic or explainable variations in an individual's critical gap, (ii) random or unexplainable variations in an individual's critical gap, and (iii) heterogeneity across drivers. In this thesis, a comprehensive mathematical model of gap acceptance behaviour that explicitly incorporates these perceptual distortions and explainable and random changes in critical gap is developed.

A large body of engineering literature exists that provides expressions to compute engineering variables such as waiting time (delay), capacity, queue length, etc. These expressions are generally obtained through a comparison of the observed gap with the critical gap. The reality that the critical gap exists only in the latent world is ignored in this literature. In order to be able to use this vast body of literature, one needs to determine an image of the latent world's critical gap in the observable world. To address this, a probability equivalence based method is devised to determine the image of the latent world's critical gap in the observed world. This image is referred to as the emulator critical gap.

To estimate the parameters of the proposed model, the maximum likelihood estimation (MLE) technique is used. Likelihood functions are developed for the same. To evaluate model performance, extensive gap acceptance data is collected as a part of this study at two different sites.

The estimation results demonstrate the effectiveness of the proposed models in representing the gap acceptance behaviour. For example, the use of the emulator critical gap obtained from the proposed method predicts the average waiting time of the people more closely than the use of the critical gap obtained from other existing methods. This highlights the better engineering usability of the proposed method.

From a behavioural perspective, the results provide valuable insights into the critical gap and the underlying decision-making process. For example, results show that the critical gap one employs while driving a more manoeuvrable vehicle is shorter than when driving a less manoeuvrable vehicle. Results also show that drivers are more risk-averse (i.e., they have a longer critical gap) when accepting gaps when the opposing vehicle is a large vehicle like a truck than when it is, say, a smaller vehicle. Among various other insights, one that stands out is that the critical gap appears to be significantly higher when the vehicle accepting the gap has just arrived versus when it has come to a stop, irrespective of the duration of the stoppage. While waiting time has a significant impact on the critical gap, the results also show that the number of rejected gaps can be used as a good surrogate for waiting time. In summary, the results corroborate the initial predictions on the nature of influence different variables must exert and give strength to the gap acceptance decision-making construct proposed here.

In addition, the proposed model suggests that if unexplainable random variations are not explicitly accounted for, they are incorrectly attributed to other parameters. Despite the

complexity in the model due to the inclusion of three sources of random variations, the estimation process can successfully separate these random variations.

The parameters of the gap acceptance models are used in various applications, such as estimating delay and capacity at intersections. In these applications, one needs to know the distribution of gaps along with the gap acceptance parameters. If one has the complete gap data (like in the present case), they can simply use that empirical distribution of gaps. However, in most real-world scenarios, only the traffic flow rate without the specific gap sequences is available. In these cases, one should have an understanding of the theoretical distribution of the gaps for the given flow rate.

Note that gaps are the time duration between the arrival of two successive vehicles at a section of the road. In a single lane orderly stream, gaps are the same as headways, but in a multi-lane orderly stream, these are different. In a disorderly stream, vehicles do not follow any lane and headways in the traditional sense cannot even be defined. Therefore, this thesis addresses the problem of finding the distribution of gaps, particularly in the case of multi-lane orderly and disorderly streams, where headway distributions cannot be used. An analytical framework is developed to specify the distribution of gaps for such streams. This analytical framework is built using the Renewal Process Theory. A maximum likelihood based process for the estimation of the parameters of the analytically derived distribution is also described. Gap data from three sites are used to see how well the analytically derived distribution function. The results show that the derived distribution function ably describes the observed gap distributions. The analytical results also predict that for wide disorderly streams, the exponential distribution is a good description of the distribution of gaps.