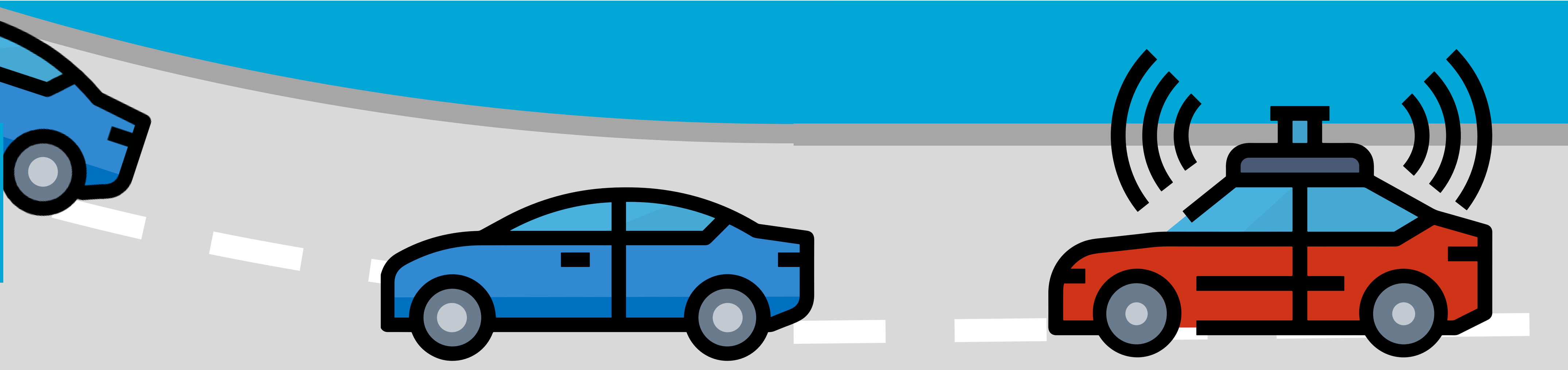
TU Delft Transport & Planning



Minimising Missed and False Alarms: A Vehicle Spacing based Approach to Conflict Detection

Open-sourced code at GitHub

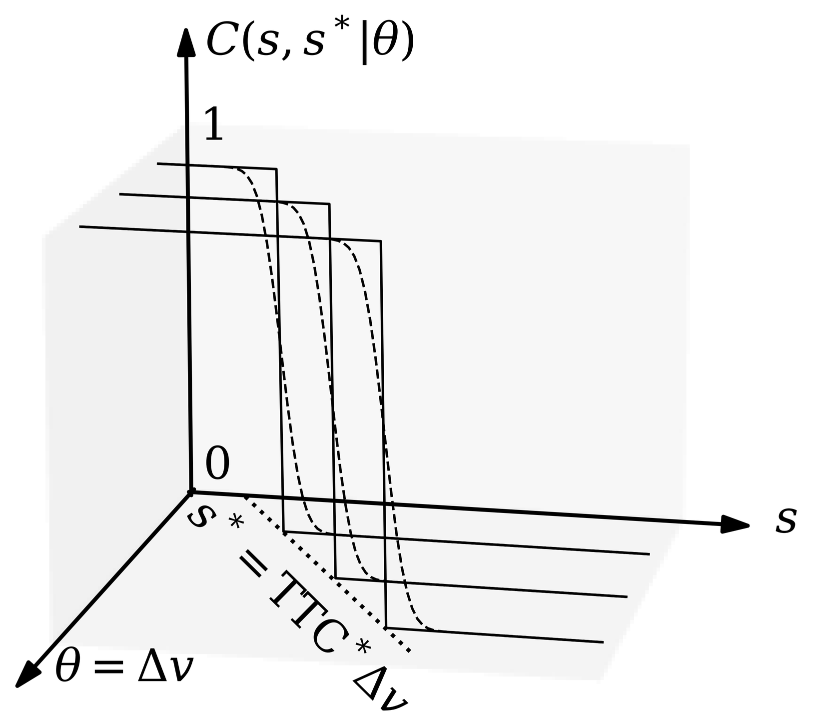
THE AUTHORS

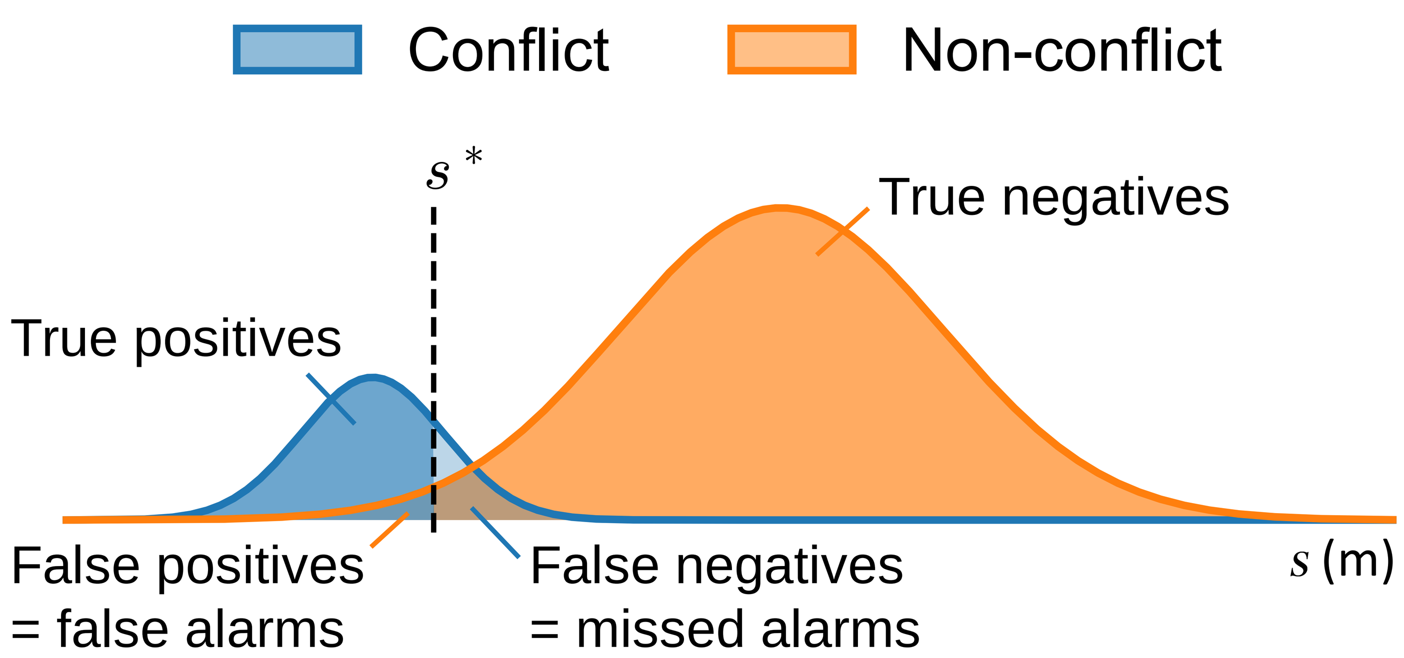
Yiru Jiao
y.jiao-1@tudelft.nl
Simeon C. Calvert
s.c.calvert@tudelft.nl
Hans van Lint
j.w.c.vanlint@tudelft.nl
Delft University of Technology

This study proposes a data-driven approach based on spacing patterns to minimize missed and false alarms in conflict detection. Our experiments show that this method

- **outperforms single-threshold TTC unless conflicts happened in the exact way that TTC is defined;**
- **achieves less missed and false detection when conflicts are heterogeneous and when the information of conflict situation is incompletely known – as is the reality.**

CONCEPTUAL IDEA





In a certain interaction situation θ, conflict detection can be seen as a binary classification based on vehicle spacing s and a critical threshold s^*. The probability distributions of conflict spacing and non-conflict spacing may overlap. Therefore, determining the critical value s^* for every interaction situation involves a trade-off between missed and false alarms.

METHODS

$$X_{ij}^t = \{s_{ij}^t, \theta_{ij}^t\}$$

The information used to evaluate an interaction scenario between vehicles i and j at a time moment t is X_{ij}^t and we process it to represent the spacing between i and j, s_{ij}^t, and θ_{ij}^t encodes the conflict situation of the scenario.

$$C(X_{ij}^t) = C(s_{ij}^t, s^*|\theta_{ij}^t) = \begin{cases} \text{c, if } s_{ij}^t \le s^* \\ \text{nc, otherwise} \end{cases}$$

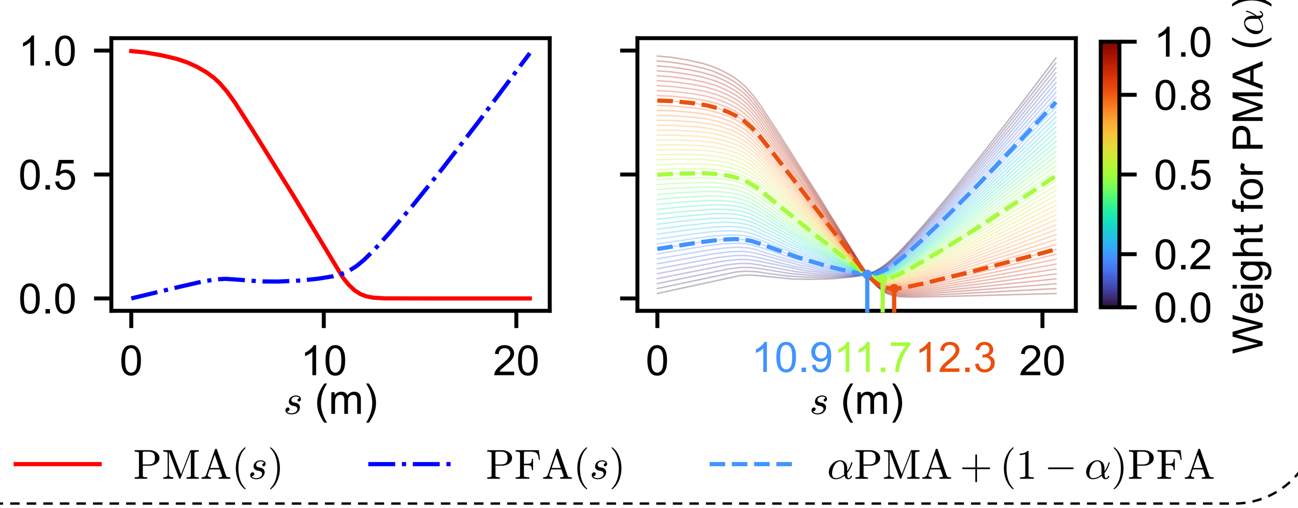
A critical value of spacing, i.e., threshold s^* is required to distinguish whether vehicles i and j are close enough to be considered as a conflict. This s^* depends on the specific situation as encoded by θ_{ij}^t.

$$\begin{cases} \text{PMA}(s) = \Pr(S > s|\text{c}) \\ \text{PFA}(s) = \Pr(S \le s|\text{nc}) \end{cases}$$

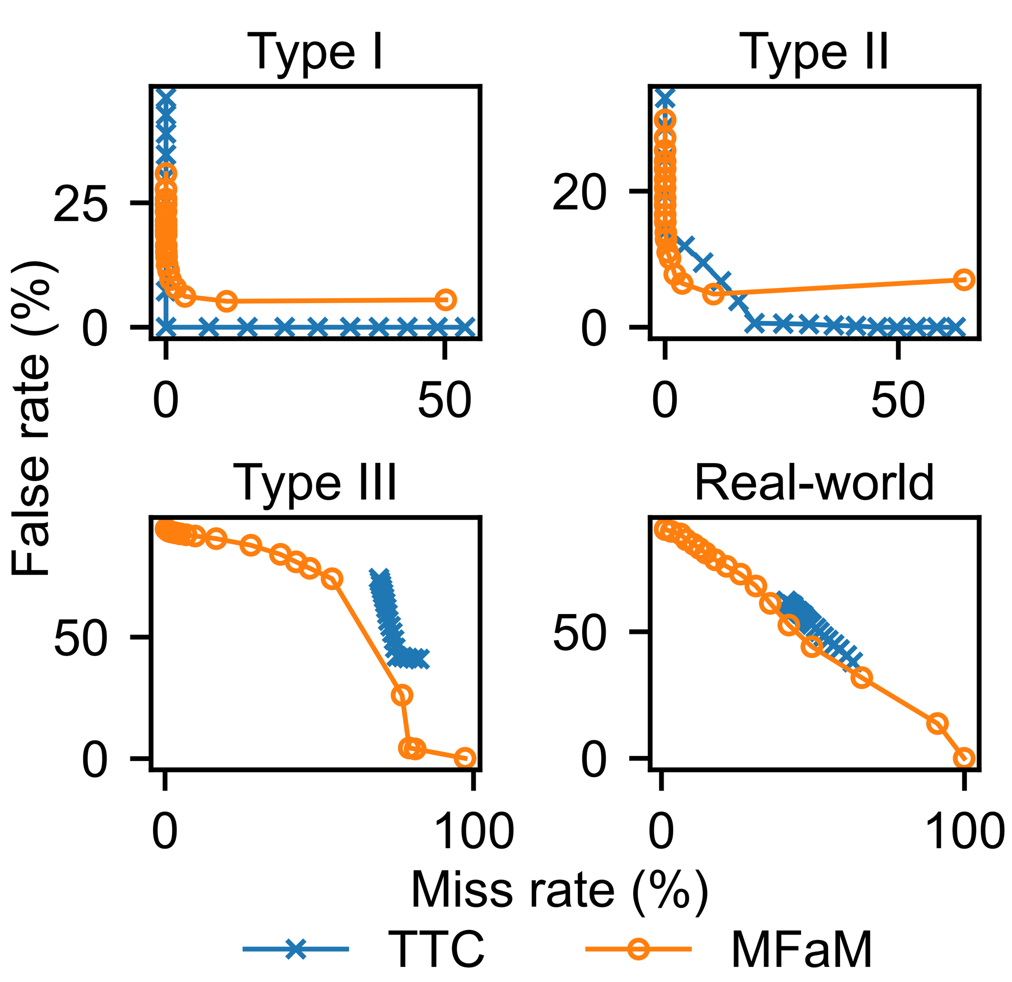
Considering the spacing between vehicles as a random variable S, we can estimate the conditional probability of missed alarms (PMA) and false alarms (PFA) from data.

$$s^* = \underset{0 \le s \le s_{\max}}{\operatorname{argmin}} \ \alpha \text{PMA}(s) + (1-\alpha)\text{PFA}(s)$$

Based on the estimated probabilities, we can optimize a critical spacing s^* which involves a trade-off between less missed alarms or less false alarms. The parameter α weighs on minimizing missed alarms.



CONCLUSION

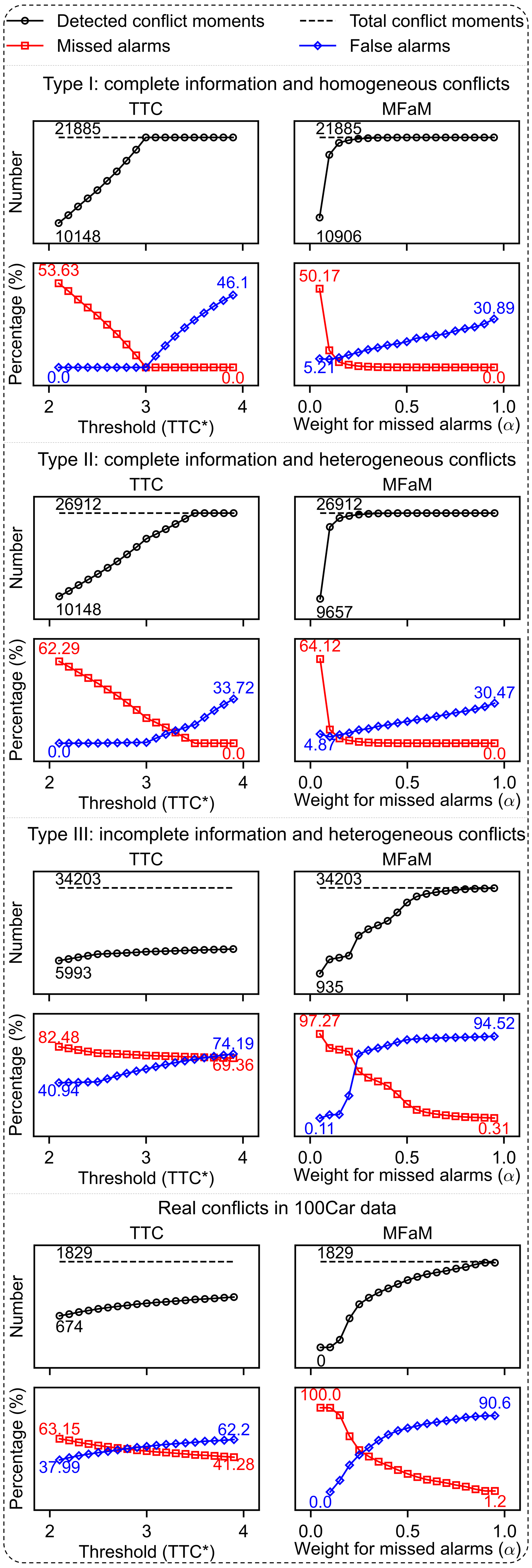


We name the threshold optimization method **MFaM**, it

- secures a better balance between missed and false alarms compared to TTC in detecting heterogeneous conflicts, both the synthetic and real-world ones;
- outperforms TTC in accurately identifying true conflicts, especially when the information of conflict situation is incomplete;
- is flexible to be extended given various vehicle spacing patterns. For example, it can be used to develop user-adaptive collision warning given that drivers perceive different levels of collision risk and react differently to automatic warnings.

All the conflict detection methods aim to approximate the optimal trade-off curve between false alarms and missed alarms, which is constrained by the available information of the conflict situations.

RESULTS



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