

Evaluating Traffic Control in Pedestrian-Vehicle Mixed Spaces Using Agent-Based Simulation Considering Personal Characteristics

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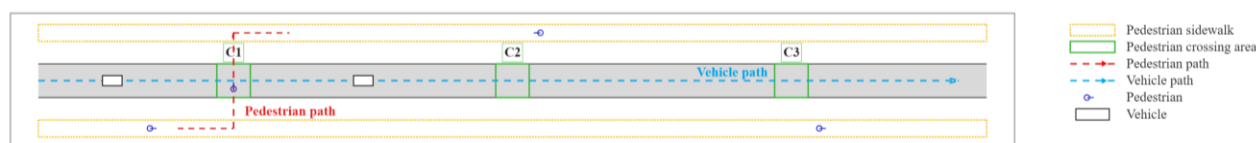


Fig. 1 Simulation environment

In recent years, achieving safe and smooth traffic flow in pedestrian-vehicle mixed spaces has become a significant social challenge. Conventional macroscopic optimization approaches and deterministic microscopic models often fail to adequately capture the probabilistic decision-making and diverse personal characteristics—such as aggressiveness or conservativeness—of actual pedestrians and drivers. In reality, these probabilistic behavioral fluctuations significantly impact the overall macroscopic traffic flow. Therefore, the primary objective of this study is to evaluate the effectiveness of various traffic control methods in pedestrian-vehicle mixed spaces using an agent-based simulation that incorporates probabilistic individual decision-making models.

To achieve this, we first modeled the crossing decisions of pedestrians and straight-driving vehicles probabilistically using a logistic regression model based on experimental data. Based on the output distribution, traffic participants were classified into distinct personal characteristics, ranging from aggressive to conservative. As shown in Fig. 1, we established a simulation environment assuming a one-way road with three consecutive crosswalks (C1, C2, and C3). We executed various traffic control scenarios exclusively at the central crosswalk (C2): an un-signalized baseline (P0), a traffic guard providing dynamic guidance (P1), and fixed-cycle signals with different green-time splits (P2–P6). The simulation evaluated multiple traffic volumes while varying the mixture ratio of aggressive and conservative agents.

The simulation results revealed that under fixed-cycle signal conditions (P2–P6), the average vehicle arrival time is maximized when the ratio of aggressive to conservative vehicles is mixed at 50% each. Sectional travel time analysis, as shown in Fig. 2, demonstrated that this delay significantly amplifies in the downstream section between C2 and C3. This delay is caused by platoon fragmentation: conservative vehicles excessively decelerate, creating large gaps that prompt waiting pedestrians to cross, which in turn forces subsequent vehicles to stop unnecessarily.

Finally, we evaluated the trade-off between traffic efficiency and safety across all scenarios, as shown in Fig. 3. The results demonstrated that while un-signalized conditions (P0) pose severe safety risks with aggressive participants, and fixed-cycle signals exacerbate delays under mixed characteristics, flexible control methods capable of dynamic guidance, such as the traffic guard (P1), are highly effective at optimizing both safety and efficiency. In conclusion, our analysis clarified the mechanism by which mixed individual decision-making characteristics amplify delays in macroscopic traffic flow, highlighting the necessity of designing optimal infrastructure tailored to regional behavioral diversities.

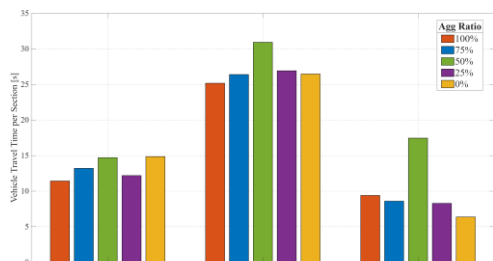


Fig. 2 Average vehicle travel time per section under varying personal characteristic ratios

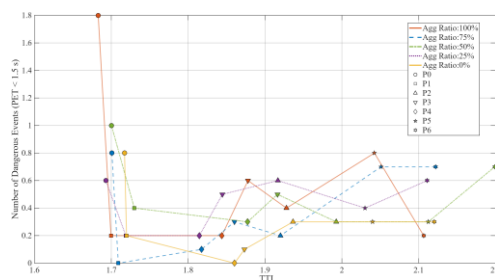


Fig. 3 Evaluation of efficiency and safety under varying traffic control scenarios (Pedestrian Vol. = 2160 ped/h)