

Evaluation of Automated Vehicles in the Frontal Cut-in Scenario - an Enhanced Approach using Piecewise Mixture Model

Ding Zhao, Assistant Research Scientist

Zhiyuan Huang, Henry Lam, David J. LeBlanc, Huei Peng

University of Michigan, Ann Arbor

AV Evaluation is Critical



Tesla Autopilot Fatal Crash, May, 2016



Google Car Accident, Sep, 2016



Uber Self-driving Rollover, March, 2017



Current Evaluation Methods

Test matrix

Pro: easy to execute, fast

Con: Pre-announced



Naturalistic Field Operational Tests

Pro:

The real-world!

❖ 100 million mi / fatal crash (NHTSA 2013)

Con:

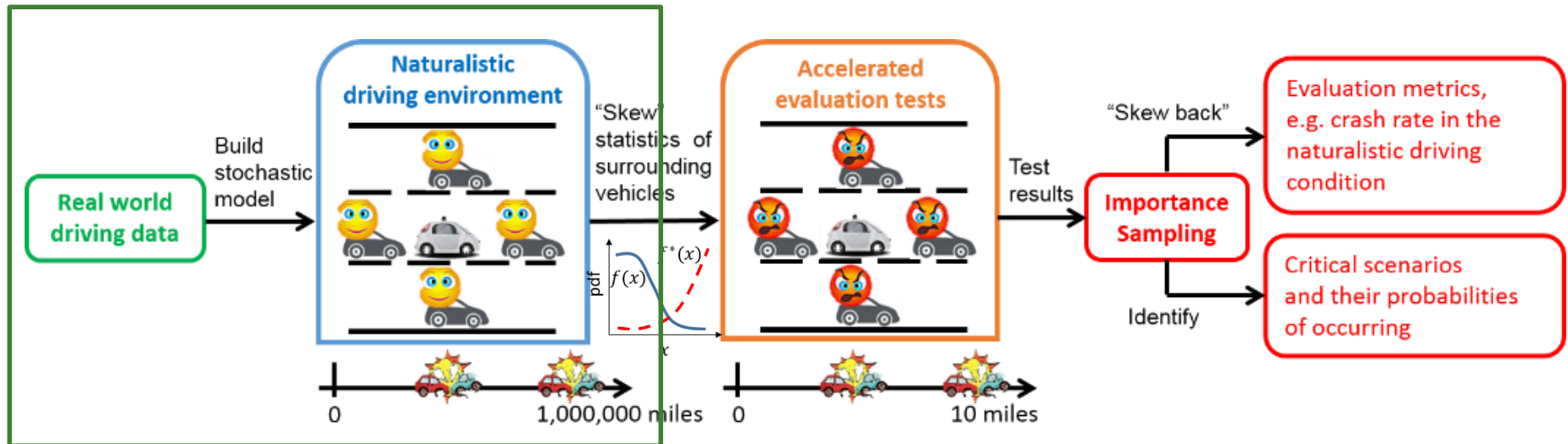
Slow, expensive

Low exposure to safety critical cases

Earth from Sun: 93 million mi

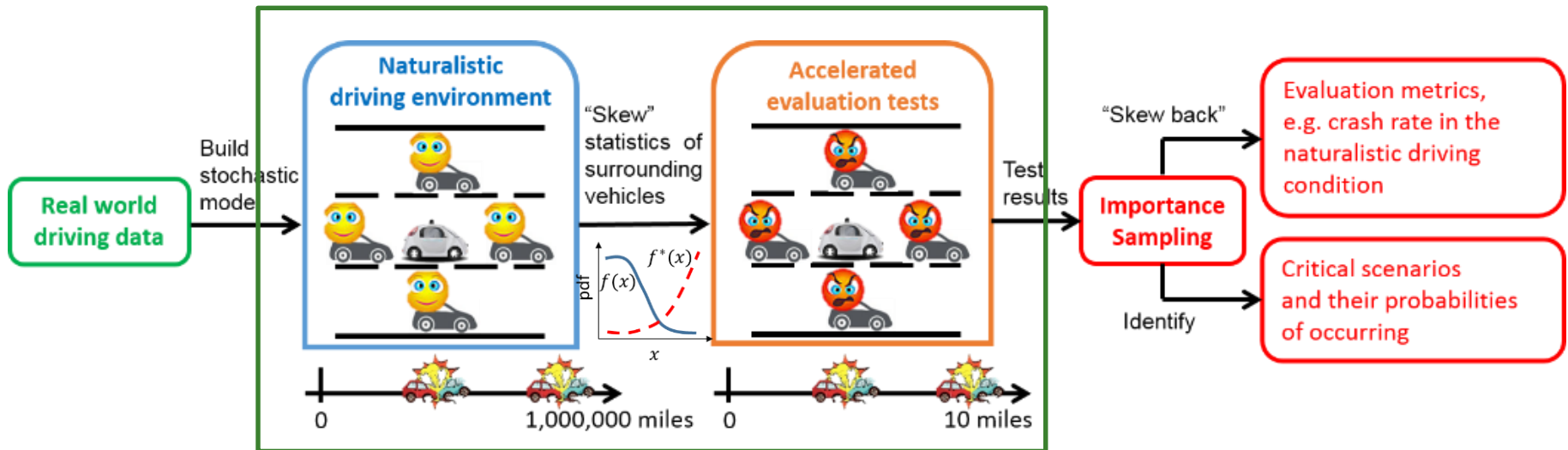


Concept of Accelerated Evaluation



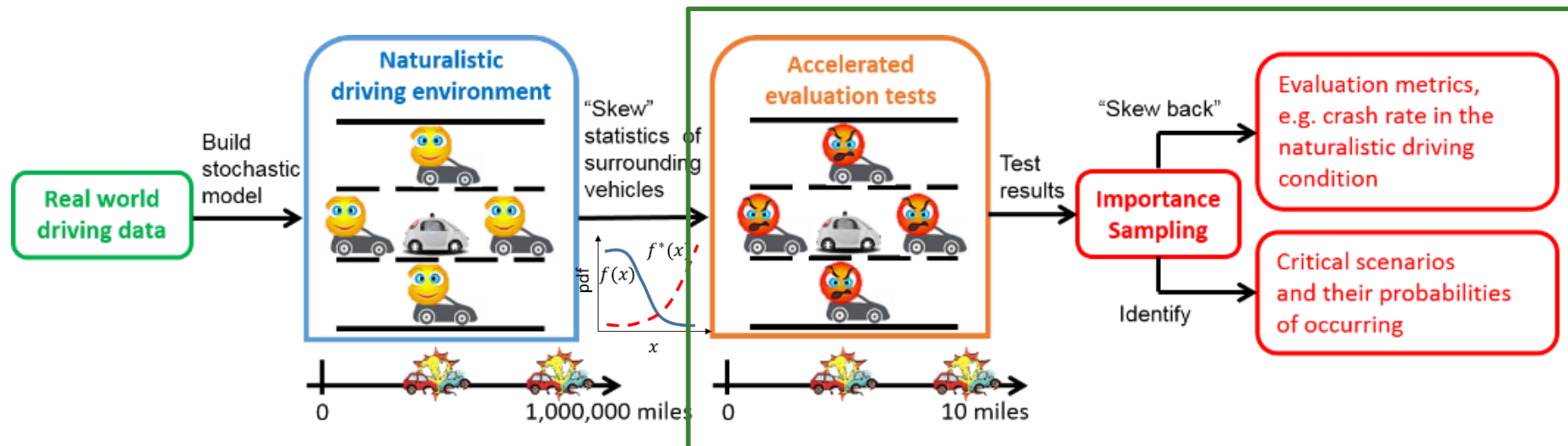
Naturalistic Driving Environment

Concept of Accelerated Evaluation



Accelerated Testing Model

Concept of Accelerated Evaluation



Interpret the accelerated results

Find the Optimal IS Distributions

Exponential twisting

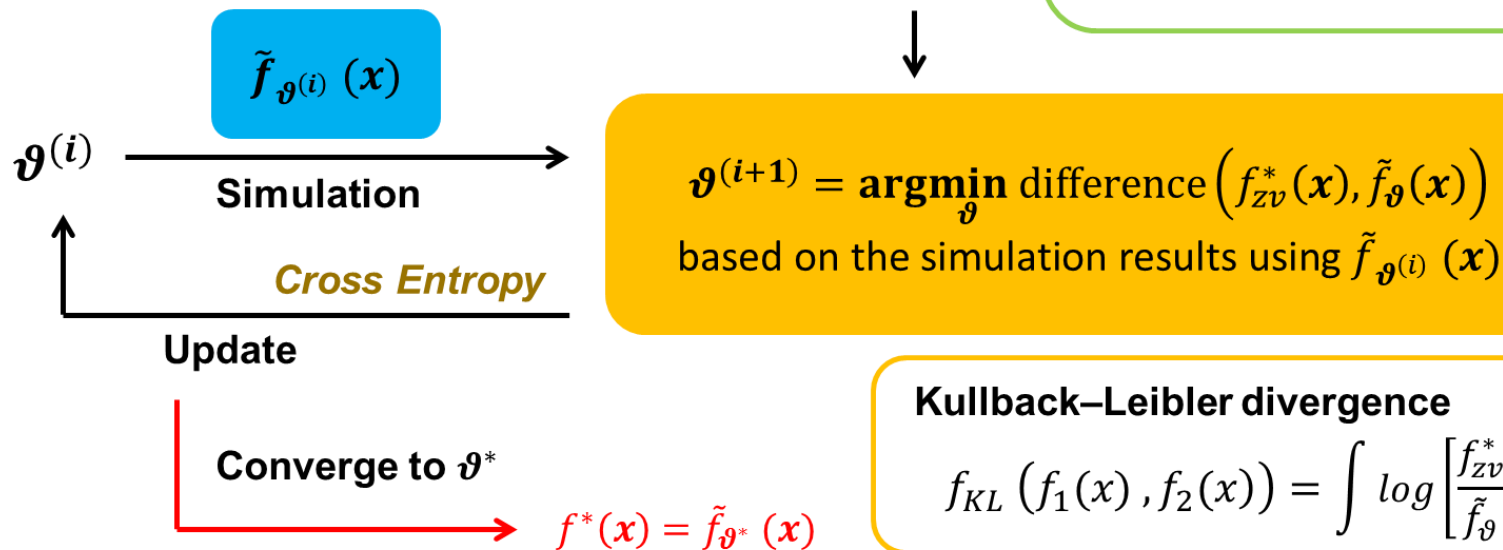
$$\tilde{f}_{\vartheta}(x) = \exp(\vartheta x - \Psi(\vartheta)) f(x)$$

$$\Psi(\vartheta) = \log E(\exp(\vartheta^T x))$$

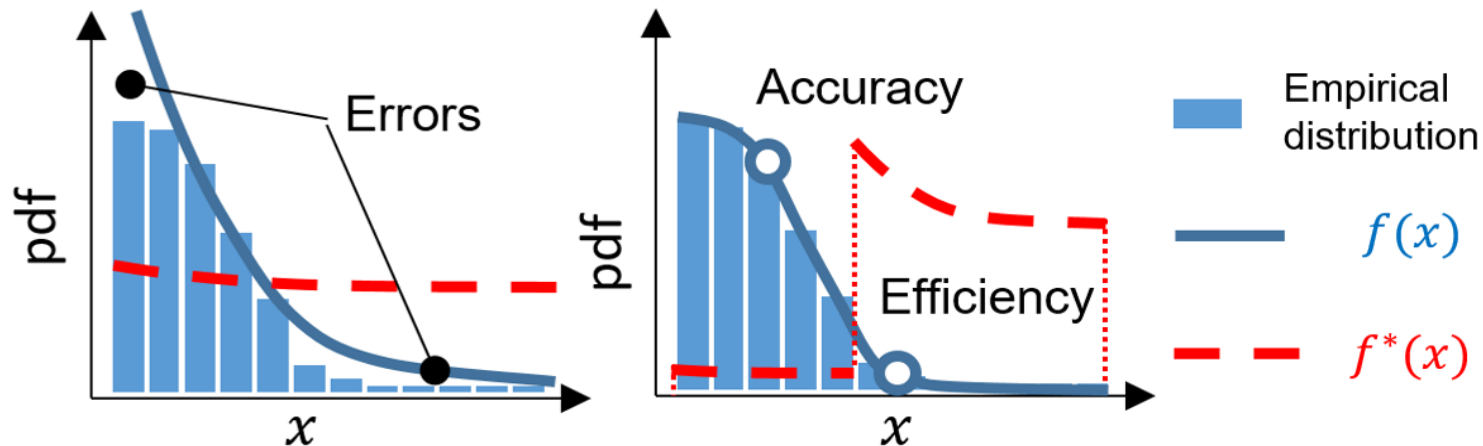
Theoretically optimal $f^*(\cdot)$

$$f_{zv}^*(x) = \begin{cases} \frac{f(x)}{\gamma}, & I_{\varepsilon}(x) = 1 \\ 0, & I_{\varepsilon}(x) = 0 \end{cases}$$

$$f_{zv}^*(x)$$



Piecewise Mixture Model



Accelerated Evaluation based on

a) a single distribution

b) a piecewise mixture distribution

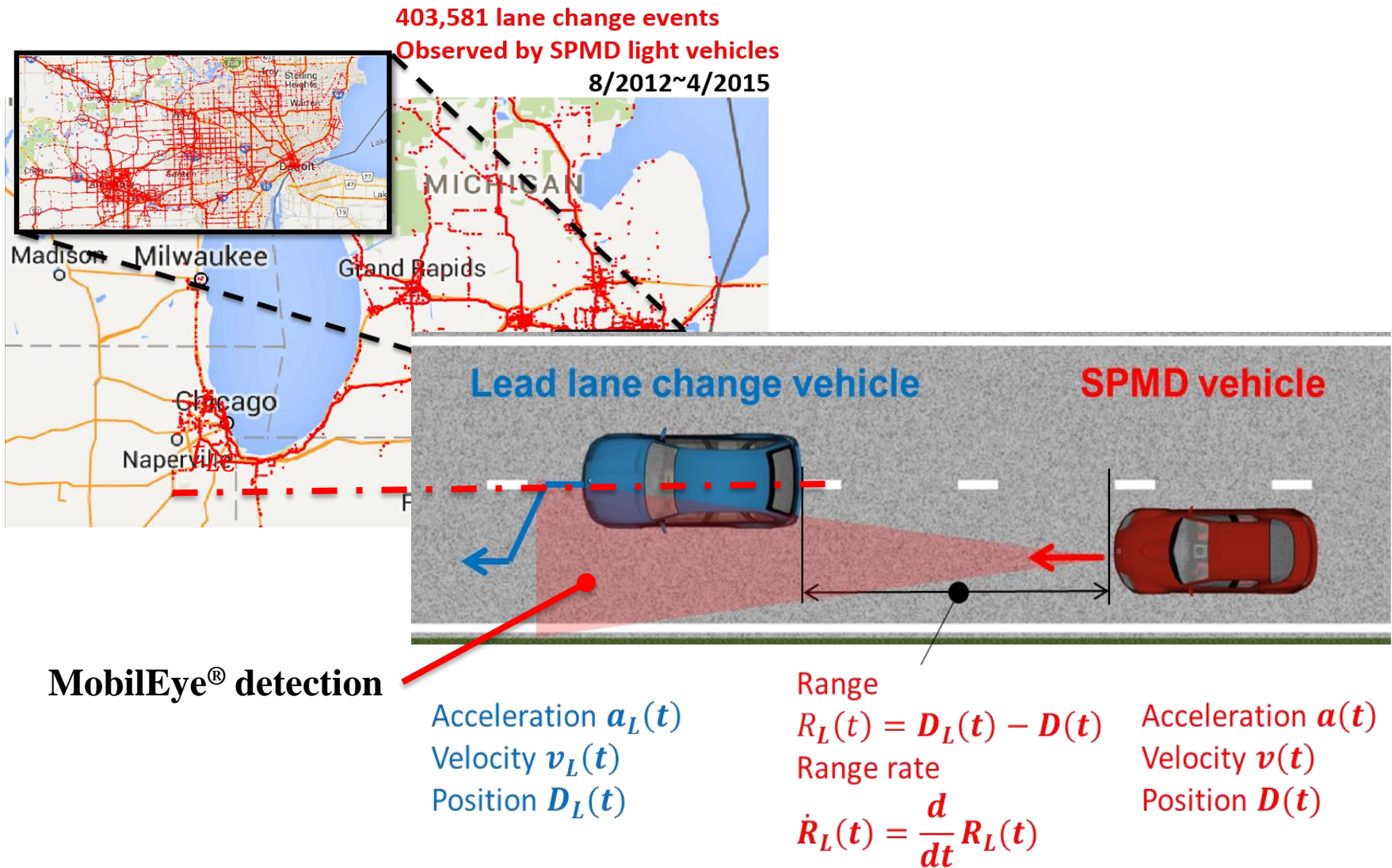
■ Fitting

- Maximum Likelihood
- Distributions in exponential family is preferred

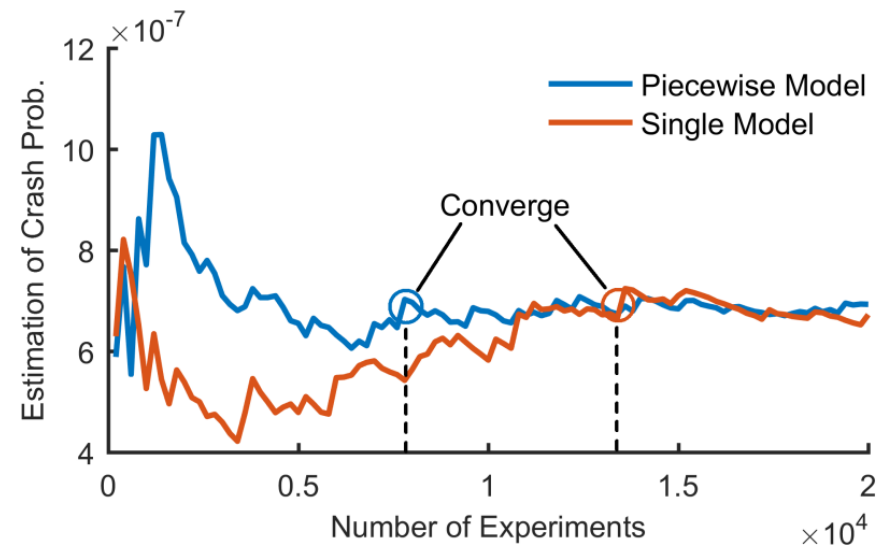
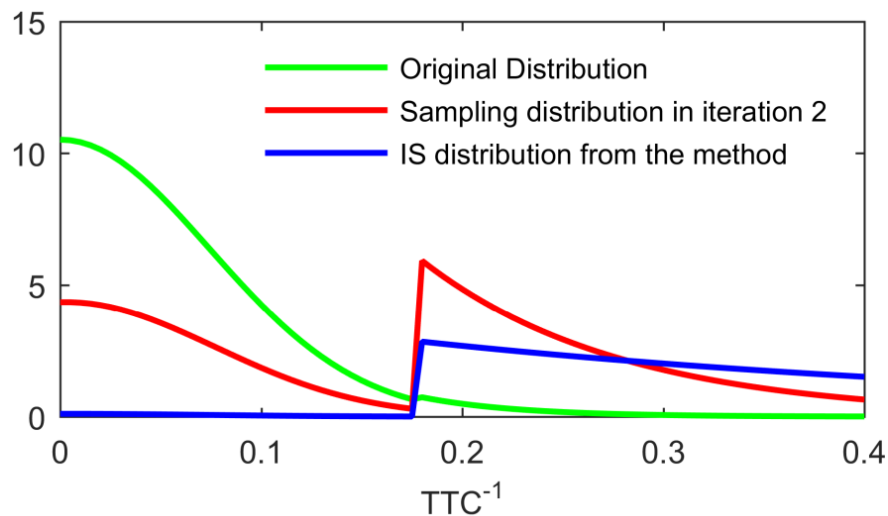
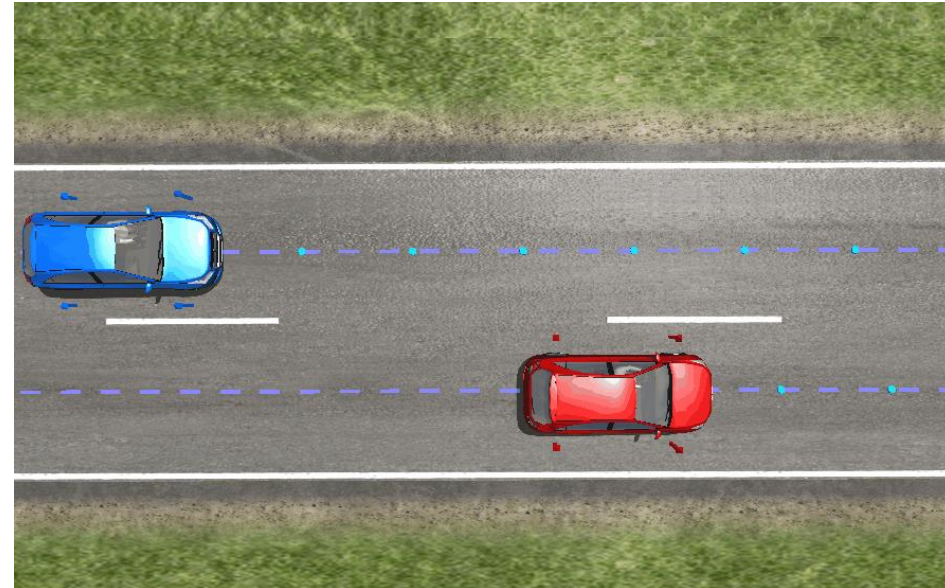
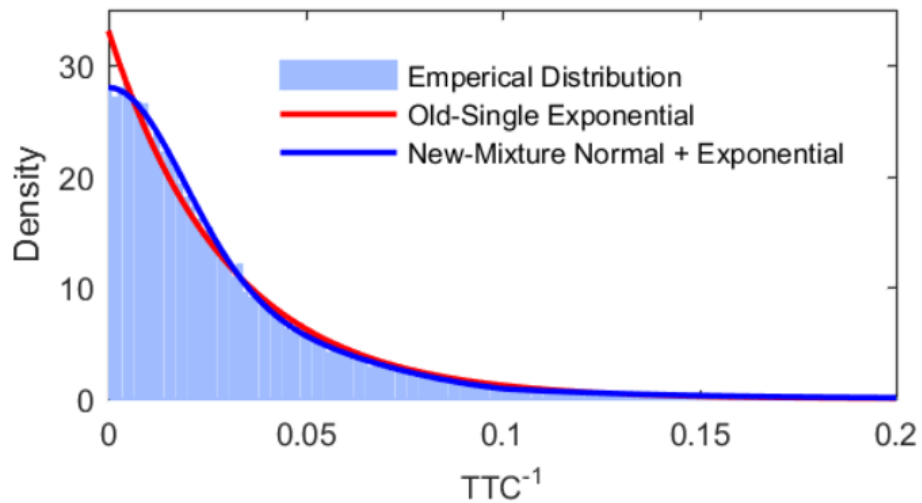
■ Calculate the IS distribution

- Modified Cross Entropy
- Floating truncation points and weight of components

Frontal Cut-in (Lane Change) Scenarios



Simulation Results



Thanks for your attention

PPT



Papers / Contact

