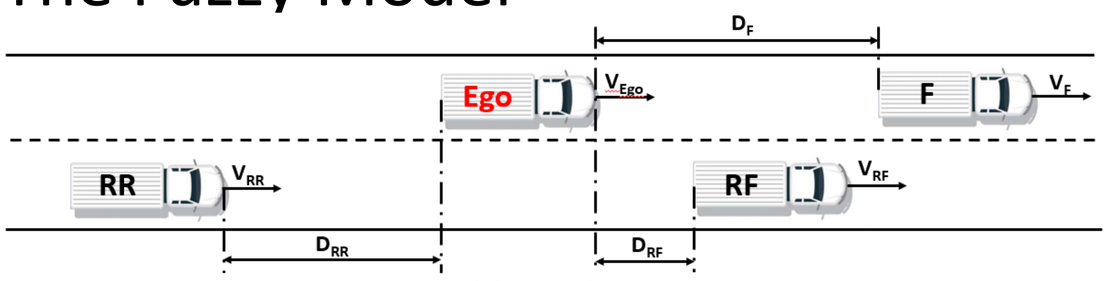
Modeling of a Truck Driver During Lane-Change Using Fuzzy Logic

Introduction

Lane changing is one of the most frequent and fundamental activities in highway driving. However, dangerous lane changes are also one of the major causes of traffic accidents and violations. Lack of confirmation due to driver inattention and driving fatigue is considered the primary cause.

This study aims to propose a driver's lane change decision-making model that incorporates factors, including inter-vehicle distance and relative velocity, into fuzzy inference. Membership functions of the fuzzy model will be determined based on results from manual driving simulator experiments. To accommodate various driving habits and preferences, the proposed fuzzy model is designed with three types: aggressive (Model A), moderate (Model M), and conservative (Model C). Additionally, each driver's manual driving data is used to generate personalized models (Model P). The validity of the models is examined through mathematical simulations.

The Fuzzy Model

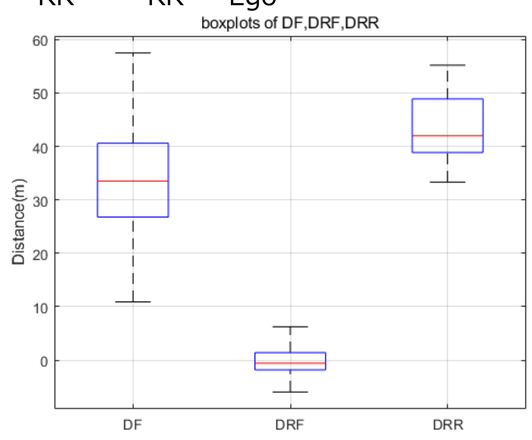


Variable Definition

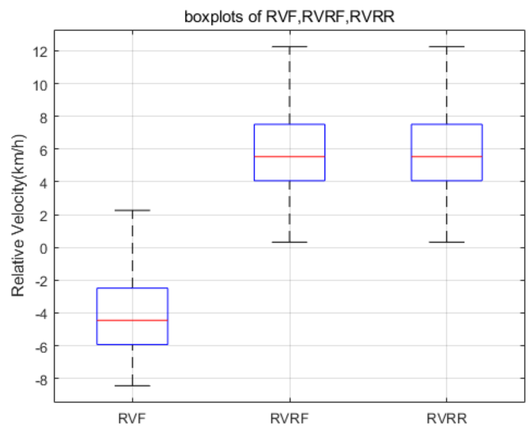
This includes six membership functions:

Inter-vehicle Distances : D_F, D_{RF}, D_{RR}

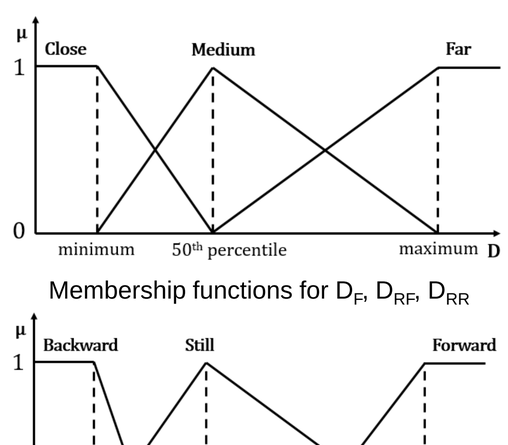
Relative Velocities : $RV_F=V_F-V_{Ego}$, $RV_{RF}= V_{RF}-V_{Ego}$, $RV_{RR}= V_{RR}-V_{Ego}$



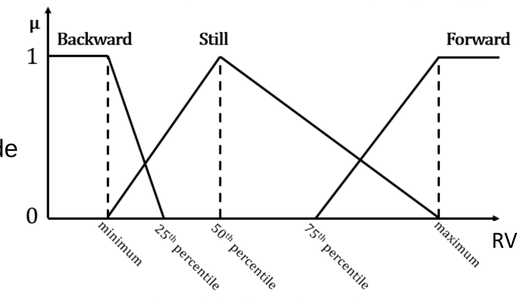
D_F, D_{RF}, D_{RR} when manual lane-changes were made



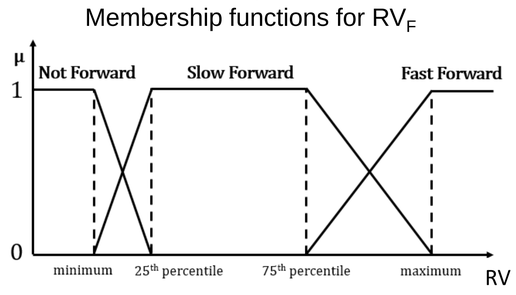
RV_F, RV_{RF}, RV_{RR} when manual lane-changes were made



Membership functions for D_F, D_{RF}, D_{RR}



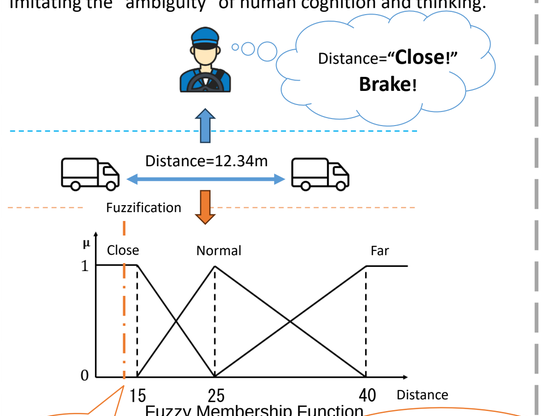
Membership functions for RV_F



Membership functions for RV_{RF}, RV_{RR}

What is Fuzzy Logic?

Imitating the "ambiguity" of human cognition and thinking.



Fuzzy Membership Function

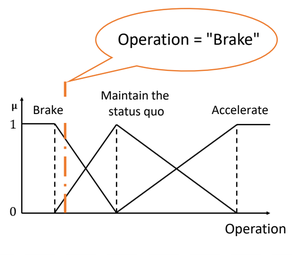
Distance="Close"

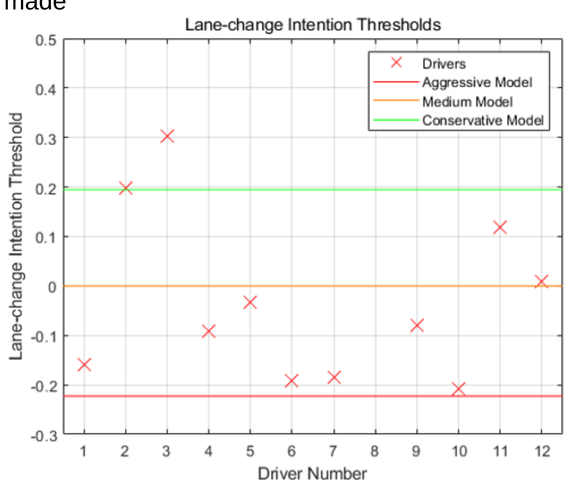
Expected Distance="normal"
*Preconfigured in this example.

Distance \ Expected Distance	Close	Normal	Far
Close	Maintain the status quo	Brake	Brake
Normal	Accelerate	Maintain the status quo	Brake
Far	Accelerate	Accelerate	Maintain the status quo

Fuzzy Rules

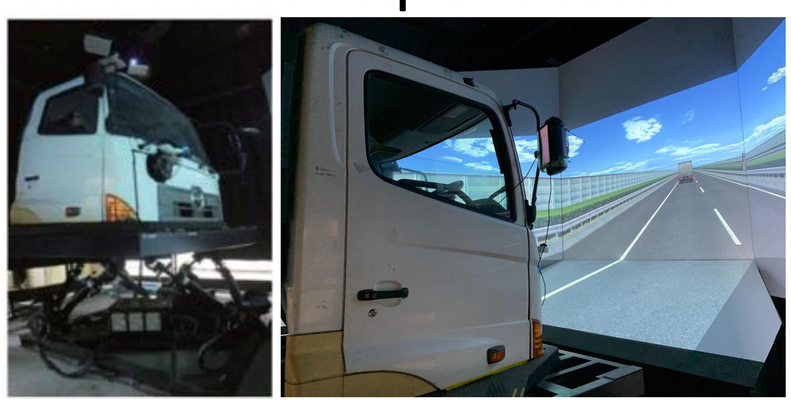
Defuzzification
*Many ways to do it



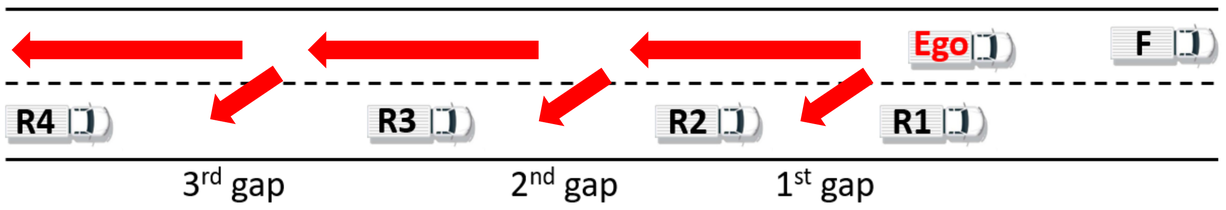


Different types of and personalized models

Driving Simulator Experiment



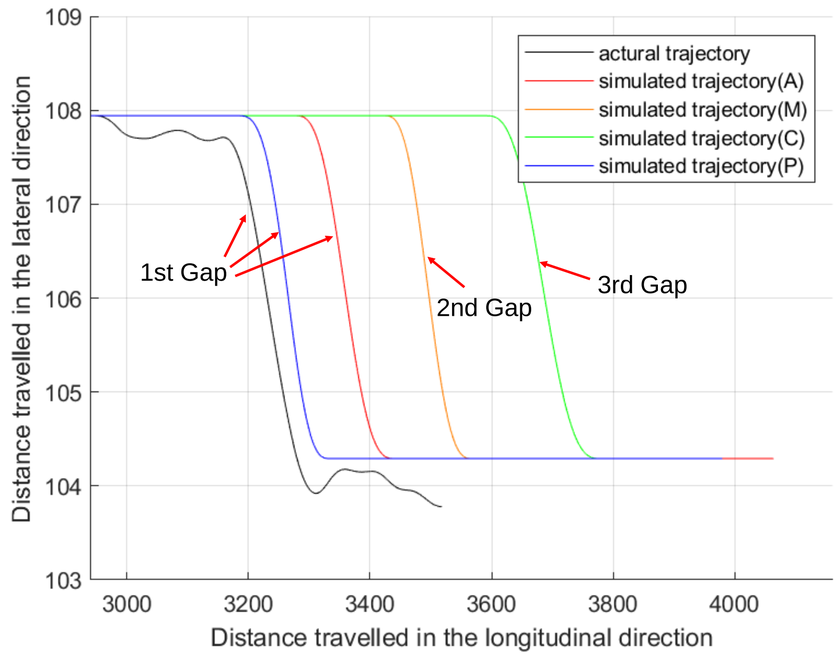
The truck cabin is installed on a 6-degree-of-freedom motion platform. A four-sided screen is in the front including the front lower one. Using a truck model (Gross Vehicle Weight: 24 t).



The experimental participants were 12 professional drivers (approved by the University of Tokyo Ethics Committee).

At the start of the scenario, all vehicles are traveling at 80 km/h. After a certain period, the lead vehicle F decelerates at 5 m/s^2, reaching a speed of 70 km/h. Subsequently, it maintains a speed of 70 km/h until the end of the scenario. The ego vehicle also decelerates to 70 km/h and searched for a gap in the adjacent lane suitable for lane change.

Mathematical Simulation Validation



Conclusion

The different types of decision-making models presented in this paper can make different lane-change decisions under the same conditions.

The personalized models closely mimic each driver's lane change decision-making style.

Publications

Guan, Muhua, et al. "A classified driver's lane-change decision-making model based on fuzzy inference for highly automated driving." 2021 IEEE 2nd International Conference on Human-Machine Systems (ICHMS). IEEE, 2021.