Modeling two-vehicle interaction at freeway - on ramp merging section with game theory

ゲーム理論を用いた高速道路合流部での二車相互作用のモデリング

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1. Introduction

- Accurate modelling of merging interactions is important for designing freeway on-ramps and developing traffic management policies.
- Previous studies of merging behaviour either did not consider the impact of the merging and through drivers on each other or did not capture the mechanism of drivers’ decision making.
- This study introduces a model of merging behaviour that aims at realistically reproducing the mechanism of drivers’ decision making.

2. Model formulation

- **Game**: non-cooperative, complete information.
- **Set of actions** of Driver $i$:
  $\mathcal{A}_1 = \{\text{merge, wait}\}, a_1 \in \mathcal{A}_1$;
  $\mathcal{A}_2 = \{\text{yield, block}\}, a_2 \in \mathcal{A}_2$.
- **Vector of actions**: $a = (a_1, a_2)$;
- **Decision time**: the earliest moment when Vehicle 1 is located on the ramp and Vehicle 2 enters the interaction interval.

3. Parameter Estimation

- The utility function for Driver $i$ is formulated as:
  $$u_a^i = \beta^0 + \beta^1 \Delta x + \beta^2 \Delta v + \epsilon_a$$
- The parameters are estimated with the method proposed by Bajari et al. that has theoretical guarantee.
- We suppose that drivers would perform the actions that form Nash equilibrium and we implement the equilibrium selection mechanism.

4. Empirical analysis

- “Zen Traffic Data” (zen-traffic-data.net) obtained on Hanshin Expressway is used for empirical analysis;
- 200 meters long merging section was selected;
- 1239 cases of merging interaction were found;

5. Conclusion

Our model demonstrates acceptable prediction ability of the merging situations but does not clearly distinguish between the non-merging cases. Prediction of these cases can be improved in the future through extension of the model to dynamic version and adoption of a gap selection mechanism.