講演番号	037

文献番号	20225037

Model Predictive Vehicle Speed Control for Mainlane Vehicles Considering Merging Vehicles

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KEY WORDS: **Intelligent, Driver model, Control system/Software,** Model predictive control **[E1]**

In the near future, it is expected that both autonomous and manually driving vehicles are mixed in the driving environment. One of the challenges for autonomous driving technology in such a traffic environment is planning vehicles considering interactions with manually operated surrounding vehicles. When certain communications such as vehicle-to-vehicle (V2V) communications are not available, the autonomous driving system is required to understand the intentions of other vehicles from the behavior of other vehicles and achieve consensus with other surrounding vehicles while considering the interactions with others. One of the typical driving situations that require consideration of interactions is merging on a highway. The merging vehicle and the mainline vehicle have to decide whether to go ahead or behind within a short period, and whether to yield or not. Both vehicles must understand each other's intentions from their respective movements and reach a consensus before making a lane change.

In this study, we propose a mainline vehicle speed control method to reduce vagueness in the decisions of other vehicles in the vicinity and to ensure smooth merging.

The driving envirionment as shown in Fig. 1 is a target, where the mainline vehicle (Car E), which is the control target, is autonomous vehicle, and the merging vehicle (Car M) and other mainline vehicles (Car 1~N) are manually operated vehicles. The overview of proposed vehicle speed controller for mainline vehicle (Car E) is shown in Fig. 2. The proposed controller is a model predictive type controller: it predicts the driving behavior of the merging vehicle (Car M) and the vehicles running behind Car E on the mainline. These predictions are computed based on a driver model constructed from data collected from experiments on test subjects using a driving simulator. The proposed controller uses this prediction to determine the series of acceleration that minimizes a cost function. The cost function includes the decision entropy, which takes a larger value when the decision of surrounding drivers are more vague. In other words, by performing acceleration and deceleration in such a way as to reduce the decision entropy, the vagueness of the decisions of Car M and the vehicle behind are reduced, and the time required for Car M to make a decision is shortened for mergiong.

Numerical simulation using the proposed merging speed controller for the mainline vehicle is carried out and the results show the proposed method reduces the time required to make a merging decision, as shown in Fig. 3.

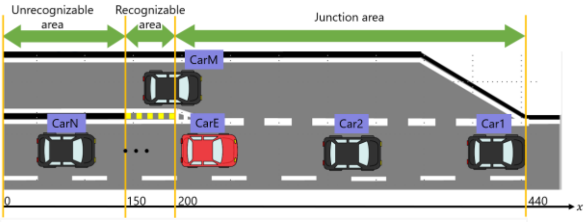

Fig. 1 Target driving envirionment

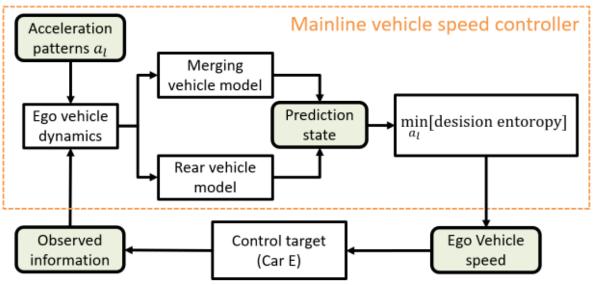

Fig. 2 Proposed vehicle speed controller for mainlane

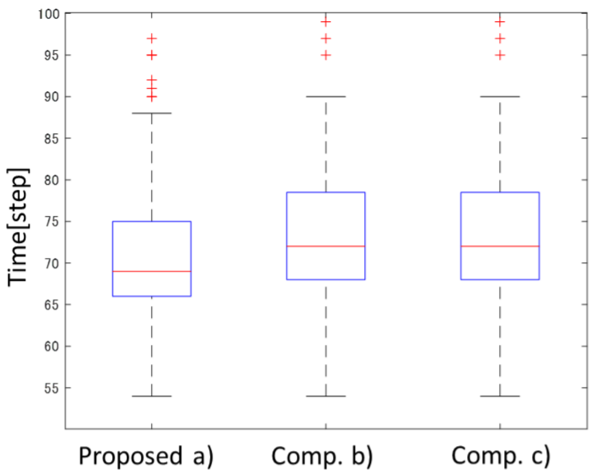

Fig.3 Comparison of time required to make a merging decision