

An Integrated Framework for Predicting Vehicle-to-Vehicle Interactions and Planning Based on GameFormer

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In autonomous driving systems, planning is a core function that determines safe and smooth vehicle behavior. Currently, interactions between the ego vehicle and surrounding vehicles are limited to relatively simple interactions, such as following a preceding vehicle using Adaptive Cruise Control (ACC) on highways and expressways. In contrast, intersections and merging scenarios require more sophisticated interactions involving decisions regarding right-of-way and timing with other vehicles. To address this issue, deep learning-based approaches have attracted attention in recent years. In particular, Transformers can flexibly capture dependencies among multiple elements and are effective at representing complex interactions. Among them, GameFormer can predict future trajectories while considering interactions among vehicles. However, its black-box nature makes it difficult to explicitly incorporate the ego vehicle's driving intention and safety constraints. Therefore, this study proposes a motion planning framework that combines the advantages of GameFormer and model-based planning.

The proposed framework assigns model-based planning and AI-based prediction according to the temporal horizon. In the short-term horizon, changes in the behavior of surrounding vehicles are limited, and model-based planning is used to explicitly incorporate vehicle motion and the ego vehicle's driving intention. In contrast, in the medium-term horizon, interactions among multiple traffic participants and uncertainty in future behavior must be considered. Therefore, GameFormer is used to predict future trajectories while considering interactions with surrounding traffic participants.

Figure 1 shows the proposed integrated framework. In each planning cycle, GameFormer is executed twice. Based on the ego trajectory within the nearest 1.1 s of the 5-s trajectory predicted by the first GameFormer, multiple motion planning candidates reflecting different driving intentions are generated using the model-based planner. These candidates are then input to the second GameFormer as the ego vehicle's input trajectories to re-predict future trajectories while considering vehicle-to-vehicle interactions. The TTC is then calculated for each candidate, and the safest plan is selected. This enables motion planning that explicitly reflects the ego vehicle's driving intention while considering interactions among vehicles.

The proposed method was evaluated in a highway merging scenario. The ego vehicle traveled on an acceleration lane and interacted with a vehicle approaching from behind on the main lane. In the model-based planning, multiple trajectory candidates corresponding to different speed profiles, such as acceleration, deceleration, and constant-speed driving, were generated based on the ego trajectory predicted by the first GameFormer while maintaining the path geometry.

The evaluation results showed that the TTC at the merging point was approximately 1 s with GameFormer alone, whereas it improved to approximately 9 s with the proposed method. This improvement is considered to result from explicitly incorporating the ego vehicle's driving intention into the trajectory candidates, which improved the consistency of the ego vehicle's behavior and facilitated the prediction of interactions with surrounding vehicles.

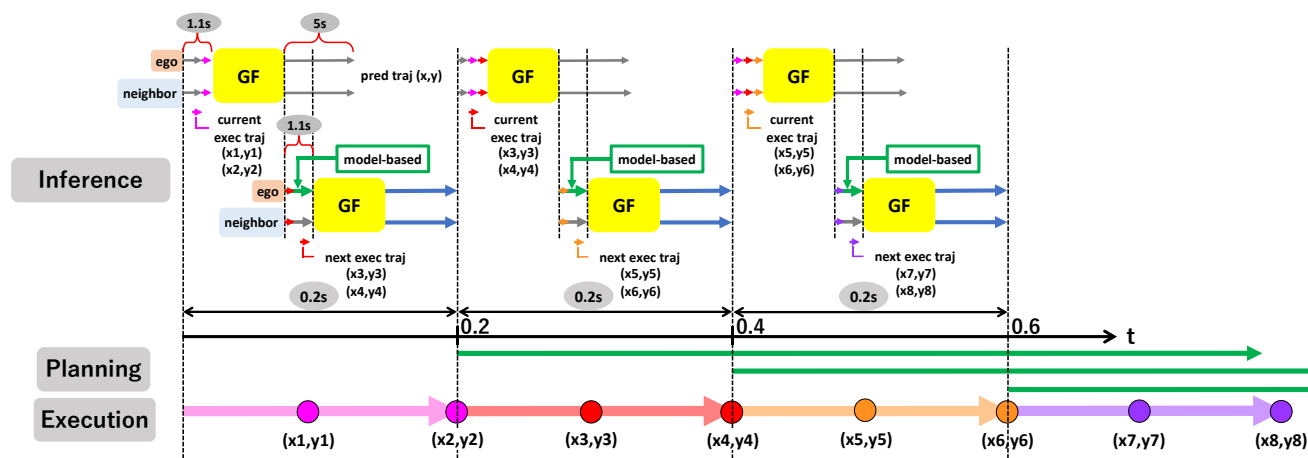


Fig.1 Overview of the proposed framework