

Modeling and simulation of overtaking behavior involving environment



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ABSTRACT

Overtaking is a complex driving behavior for intelligent vehicles. Current research on modeling overtaking behavior pays little attention on the effect of environment. This paper focuses on the modeling and simulation of the overtaking behavior in virtual reality traffic simulation system involving environment information, such as road geometry and wind. First, an intelligent vehicle model is proposed to better understand environment information and traffic situation. Then, overtaking behavior model is introduced in detail, the lane changing feasibility is analyzed and the fuzzy vehicle controllers considering the road and wind effect are researched. Virtual reality traffic simulation system is designed to realize the simulation of overtaking behavior, with realistic road geometry features. Finally, simulation results show the correctness and the effectiveness of our approach.

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1. Introduction

Research on developing intelligent vehicles to improve highway safety and efficiency is one of the most extensively studied topics in the field of Intelligent Transportation System (ITS) [1]. The microscopic driving maneuver of intelligent vehicle could be divided into three main maneuvers: car following, lane changing and overtaking. Of all the maneuvers, overtaking is one of the most complex and dangerous driving maneuvers, because it combines both lateral and longitudinal control. Thus the automation of this maneuver has been considered to be one of the toughest challenges in the development of intelligent vehicle [2].

Compared with other intelligent vehicle research, the studies of overtaking models are not very extensive. [1] was based on a stereo vision system responsible for detecting any preceding vehicle and triggering the autonomous overtaking maneuver, and a fuzzy logic based controller was developed to emulate how humans overtake. [3] presented a learning method to solve the vehicle overtaking problem, which demanded a multiple criteria. [4] proposed an overtaking control method based on the estimation of conflict probability. [5,6] proposed a fuzzy control system that essentially changes the driving mode according to the three phases. However, throughout the previous studies concerning overtaking behavior, the influence of natural environment (such as road, wind, and weather) affecting on the vehicle has been ignored in the modeling of overtaking behavior.

Moreover, it is difficult to test the overtaking behavior with real vehicles because the overtaking behavior is complex and dangerous, so traffic simulation with Virtual Reality (VR) plays an important role in this research. VR technology is increasingly being used in traffic simulation systems [7] and driving simulators [8,9]. Nevertheless, most existing research on traffic simulation with VR mainly has been concentrated on the visualization or the real-time traffic simulation in a virtual world [10,11], little work has been done to profit the virtual reality system to provide realistic environment information for simulation. Combining Geographic Information System (GIS) and VR to realize the terrain visualization could enhance the authenticity. Based on this method, the overtaking behavior could be analyzed in the VR simulation system with realistic environment information and the traffic simulation could be much more valid.

Inspired by the existing research mentioned above, modeling and simulation of overtaking behavior involving road and wind effect in virtual reality system is realized in this paper. The purpose is to better understand the road geometry and wind effect in traffic and to assist overtaking behavior analysis in traffic simulation. In previous research [12], we presented modeling overtaking behavior in virtual reality traffic simulation system, this paper focuses on the context of modeling and simulation of overtaking behaviors with the consideration of road and wind effect from the virtual world.

The remaining of this paper is organized as follows: in Section 2, the architecture of intelligent vehicle model is presented in detail, including the vehicle dynamic models considering the road geometry and wind. Section 3 introduces overtaking behavior model, the lane changing behavior model and the car following model are analyzed because they are the base of overtaking, and the fuzzy

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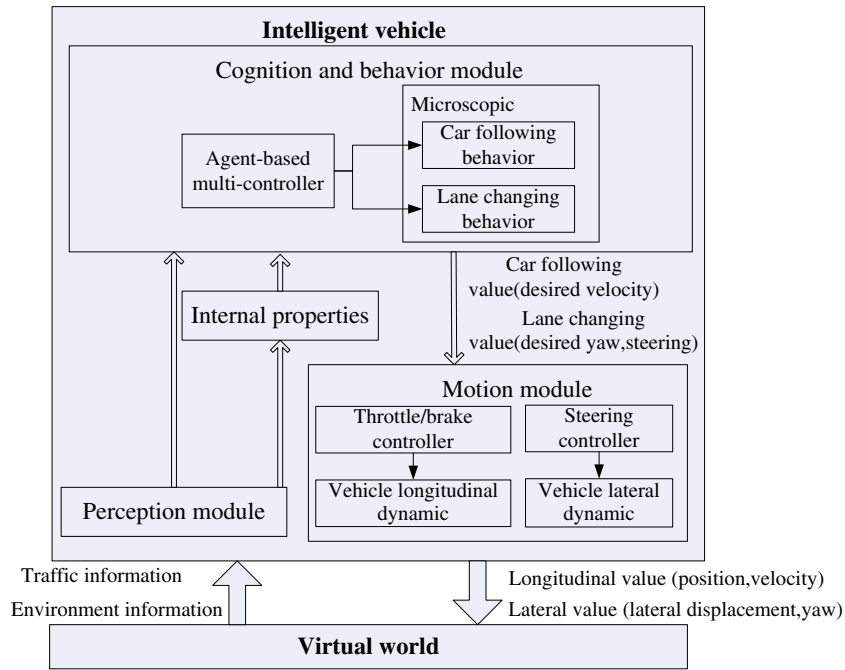


Fig. 1. Framework of intelligent vehicle.

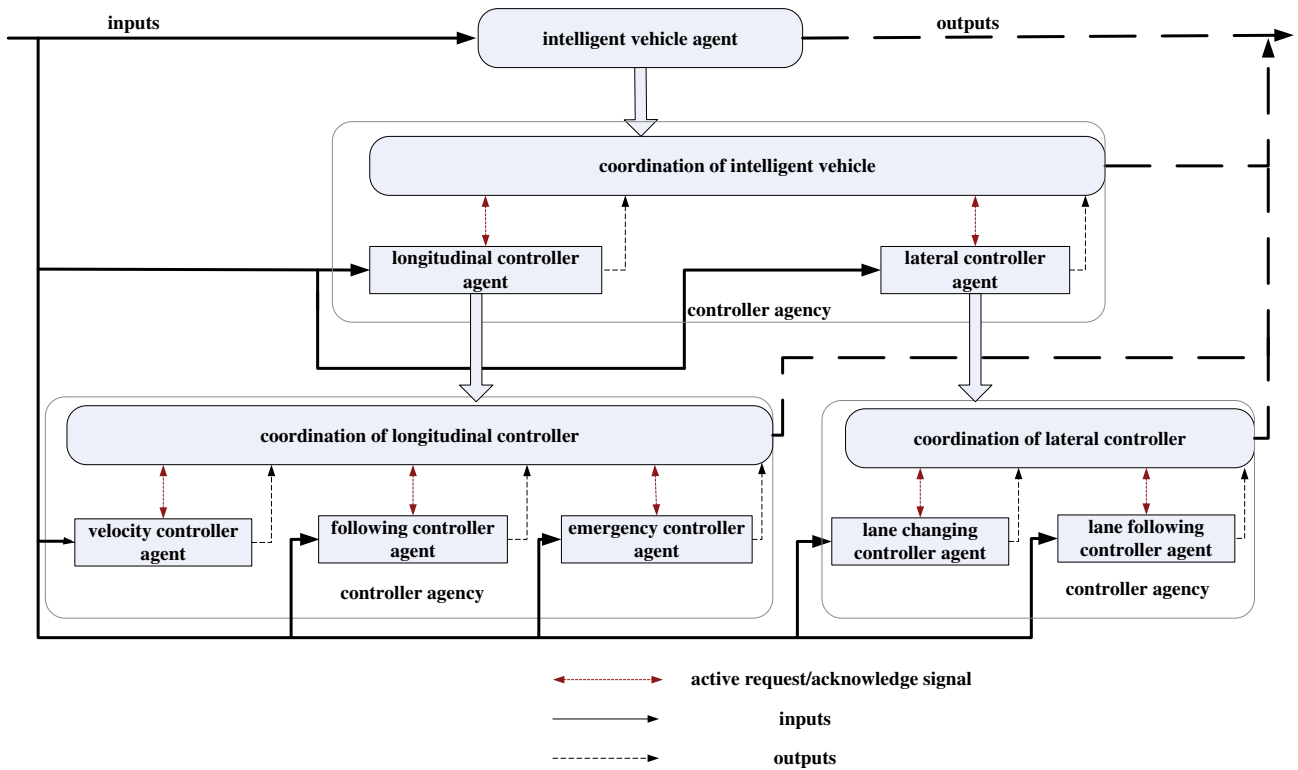


Fig. 2. Agent-based multi-controller intelligent vehicle.

logic based steering, throttle/brake controllers are designed with the consideration of road and wind effect. Section 4 realizes the overtaking behavior simulation, virtual reality traffic simulation system is described to supply realistic road geometry features. Section 5 shows the simulation maneuver and some simulation results. Finally, the paper is concluded and prospected in Section 6.

2. Modeling intelligent vehicle

The intelligent vehicle is an autonomous virtual vehicle, which is architected as a hierarchical model incorporating perception module, motion module, cognition and behavior module, and internal properties, shown in Fig. 1.

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