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Modeling Connected and Autonomous Vehicles in Heterogeneous Traffic Flow

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Abstract

The objective of this study was to develop a heterogeneous traffic-flow model to study the possible impact of connected and autonomous vehicles (CAVs) on the traffic flow. Based on a recently proposed two-state safe-speed model (TSM), a two-lane cellular automaton (CA) model was developed, wherein both the CAVs and conventional vehicles were incorporated in the heterogeneous traffic flow. In particular, operation rules for CAVs are established considering the new characteristics of this emerging technology, including autonomous driving through the adaptive cruise control and inter-vehicle connection via short-range communication. Simulations were conducted under various CAV-penetration rates in the heterogeneous flow. The impact of CAVs on the road capacity was numerically investigated. The simulation results indicate that the road capacity increases with an increase in the CAV-penetration rate within the heterogeneous flow. Up to a CAV-penetration rate of 30%, the road capacity increases gradually; the effect of the difference in the CAV capability on the growth rate is insignificant. When the CAV-penetration rate exceeds 30%, the growth rate is largely decided by the capability of the CAV. The greater the capability, the higher the road-capacity growth rate. The relationship between the CAV-penetration rate and the road capacity is numerically analyzed, providing some insights into the possible impact of the CAVs on traffic systems.

Keywords: Multi-model, connected and autonomous vehicles, cellular automaton, heterogeneous flow model

1. Introduction

Recent developments in information and communication technology have resulted in significant advancements in intelligent transportation systems (ITSs). Because of the latest developments in the automobile industry, connected and autonomous vehicles (CAVs) are coming to the fore. It is widely expected that CAVs will be available on the mass market by 2022 or 2025. Connected systems such as the vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) systems will be introduced in the transportation system along with the deployment of CAVs. These significant developments will change the highway-driving environment. Equipped with computer sensors that can help detect near objects, along with the capability of communicating with other autopilot vehicles, the driving