報告番号	甲　第　12873　号

主　論　文　の　要　旨

論文題目　**Connected and Autonomous Vehicle in Heterogeneous Traffic Flow: Modeling, Evaluation, and Management**
(混合交通流における自動運転車のモデリングおよび評価とマネジメント)

氏　名　叶　兰杭

論　文　内　容　の　要　旨

The objective of this dissertation is to develop a heterogeneous traffic flow model, in order to study the possible impact of connected and autonomous vehicles (CAVs) on future 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 were established considering the new characteristics of this emerging technology, including autonomous driving through the adaptive cruise control (ACC) and inter-vehicle connection via short-range communication. Based on the proposed heterogeneous flow model, the mixed traffic flow with both conventional vehicles and CAVs was simulated and studied.

Simulation was conducted under various CAV-penetration rates in the heterogeneous flow. The impact of CAVs on the road capacity, traffic safety, and fuel consumption was numerically

investigated. The fundamental diagrams 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 was numerically analyzed, providing some insights into the possible impact of the CAVs on traffic systems.

In terms of impact on safety and fuel consumption, the frequency of dangerous situations and value of time-to-collision in the mixed traffic flow under different CAV penetration rates were calculated and used as indicators of CAV's impact on traffic safety. Acceleration rate and velocity difference distributions of the mixed traffic flow were presented to show the evolution of mixed traffic flow dynamics with the increase in CAV penetration rates. Results show that the condition of traffic safety and fuel efficiency is greatly improved with the increase in the CAV penetration rate. A more cautious car-following strategy of the CAV would contribute to a greater benefit on traffic safety, though less gain in capacity. With the increase in CAV penetration rate, the portion of smooth driving is increased. The velocity difference between vehicles is decreased and traffic flow is greatly smoothed. Fuel dissipation rate is lowered.

Lastly, an application of the proposed methodology was presented to investigate the impact of setting dedicated lanes for CAVs on traffic flow throughput. A fundamental diagram approach was introduced which reveals the pros and cons of setting dedicated lanes for CAVs under various CAV penetration rates and demand levels. The performance of traffic flow under different number of CAV-dedicated lanes was compared with mixed flow situation. Simulation results suggest that at a low CAV penetration rate, setting CAV-dedicated lanes deteriorates the performance of the overall

traffic flow throughput, particularly under a low-density level. When CAVs reach a dominant role in the mixed flow, the merits of setting dedicated lanes also decrease. The benefit of setting CAV-dedicated lane can only be obtained within a medium density range. CAV penetration rate and individual CAV performance are significant factors that decide the performance of CAV-dedicated lane. The higher level of performance the CAV could achieve, the greater benefit it will attain through the deployment of CAV-dedicated lane. Besides, the performance of CAV-dedicated lane can be improved through setting a higher speed limit for CAVs on the dedicated lane than vehicles on other normal lanes. This work provides some insights into the impact of the CAV-dedicated lane on traffic systems, and helpful in deciding the optimal number of dedicated lanes for CAVs.