Accident Analysis and Prevention 104 (2017) 115–124

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Is vehicle automation enough to prevent crashes? Role of traffic operations in automated driving environments for traffic safety

Eunbi Jeong[a], Cheol Oh[b,*], Seolyoung Lee[c]

[a] Korea Railroad Research Institute, Transport Systems Research Team, 176 Railroad Museum Road, Uiwang-si, Gyeonggi-do, 16105, Republic of Korea
[b] Hanyang University Erica Campus, Department of Transportation and Logistics Engineering, 55 Hanyangdaehak-ro, Sangnok-gu, Ansan 15588, Republic of Korea
[c] Graduated Student Researcher, Hanyang University Erica Campus, Department of Transportation and Logistics Engineering, 55 Hanyangdaehak-ro, Sangnok-gu, Ansan 15588, Republic of Korea

ARTICLE INFO

Keywords:
Traffic safety
Automated driving systems
Traffic operations strategy
Rear-end crash risks
Market penetration rate

ABSTRACT

Automated driving systems (ADSs) are expected to prevent traffic accidents caused by driver carelessness on freeways. There is no doubt regarding this safety benefit if all vehicles in the transportation system were equipped with ADSs; however, it is implausible to expect that ADSs will reach 100% market penetration rate (MPR) in the near future. Therefore, the following question arises: 'Can ADSs, which consider only situations in the vicinity of an equipped vehicle, really contribute to a significant reduction in traffic accidents?' To address this issue, the interactions between equipped and unequipped vehicles must be investigated, which is the purpose of this study. This study evaluated traffic safety at different MPRs based on a proposed index to represent the overall rear-end crash risk of the traffic stream. Two approaches were evaluated for adjusting longitudinal vehicle maneuvers: vehicle safety-based maneuvering (VSM), which considers the crash risk of an equipped vehicle and its neighboring vehicles, and traffic safety-based maneuvering (TSM), which considers the overall crash risk in the traffic stream. TSM assumes that traffic operational agencies are able to monitor all the vehicles and to intervene in vehicle maneuvering. An optimization process, which attempts to obtain vehicle maneuvering control parameters to minimize the overall crash risk, is integrated into the proposed evaluation framework. The main purpose of employing the optimization process for vehicle maneuvering in this study is to identify opportunities to improve traffic safety through effective traffic management rather than developing a vehicle control algorithm that can be implemented in practice. The microscopic traffic simulator VISSIM was used to simulate the freeway traffic stream and to conduct systematic evaluations based on the proposed methodology. Both TSM and VSM achieved significant reductions in the potential for rear-end crashes. However, TSM obtained much greater reductions when the MPR was greater than 50%. This study should inspire transportation researchers and engineers to develop effective traffic operations strategies for automated driving environments.

1. Introduction

Worldwide interest in automated driving systems (ADSs) has increased greatly due to their ability to prevent traffic accidents on freeways. ADSs have also come to be regarded as an essential element of future transportation systems. The vehicle automation levels, which are key to fully exploiting the benefits of ADSs, were recently released by the National Highway Traffic Safety Administration (NHTSA) of the U.S. government (2013): Level 0 has no automation; Level 1 has function-specific automation; Level 2 has combined-function automation; Level 3 has limited self-driving automation; and Level 4 has full self-driving automation. As the level of vehicle automation presented by NHTSA gradually evolves, there is concern regarding how equipped vehicles will interact with unequipped vehicles in the traffic stream. ADSs are unlikely to reach a 100% market penetration rate (MPR) in the near future, which leads to uncertainty regarding the effectiveness of ADSs in terms of traffic safety.

Recently, ADSs have been partially realized by several vehicular technologies, including adaptive cruise control (ACC), cooperative adaptive cruise control (CACC), and the automatic emergency braking system (AEBS). Shladover et al. (2012) demonstrated the impacts of CACC on the traffic flow characteristics using microscopic traffic simulations. Their study showed that CACC can achieve operational efficiency in terms of increasing capacity and throughput. In addition,

* Corresponding author.
E-mail addresses: jeb0120@krri.re.kr (E. Jeong), cheolo@hanyang.ac.kr (C. Oh), lsy0717@hanyang.ac.kr (S. Lee).

http://dx.doi.org/10.1016/j.aap.2017.05.002
Received 3 February 2017; Received in revised form 27 March 2017; Accepted 1 May 2017
0001-4575/ © 2017 Elsevier Ltd. All rights reserved.

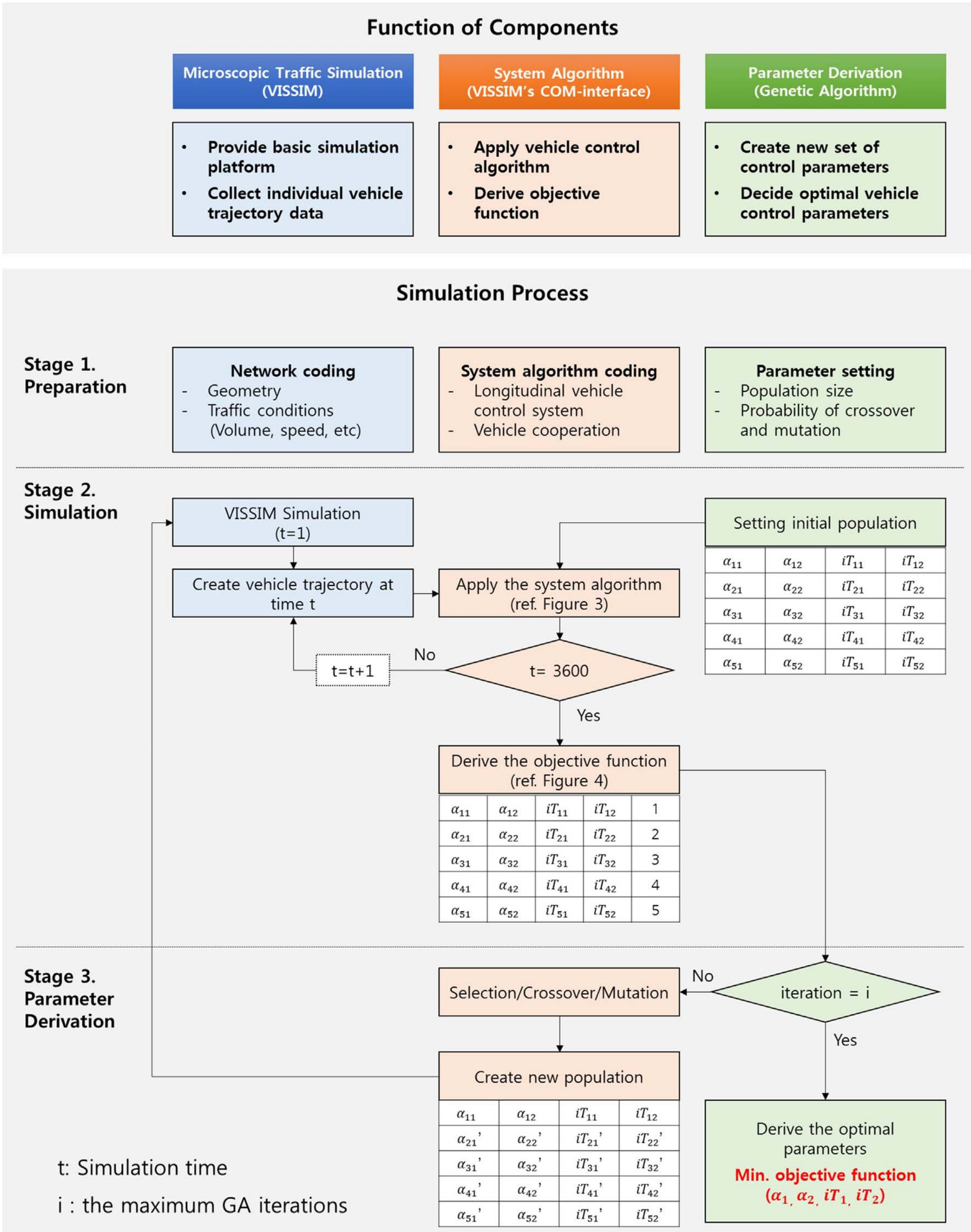

Fig. 1. Overall framework and procedure for deriving the vehicle control parameters.

significant studies have reported that the traffic flow stability, which is regarded as a surrogate for the crash potential, could be improved by longitudinal vehicular control measures, such as ACC and CACC (Shrivastava and Li, 2000; Darbha and Rajagopal, 1999; Schakel et al., 2010; Pueboobpaphan and van Arem, 2011). Van Noort et al. (2012) proposed a methodology for evaluating the safety impacts of ACC using data obtained from a field operational test (FOT) and crash statistics. Several studies have presented the limitations and issues concerning the MPR of ADSs. Van Arem et al. (2006) and Arnaout and Bowling (2011) investigated the impact of CACC on the traffic flow stability and reported that a low MPR for CACC (< 40%) does not affect traffic flow throughput. In addition, Hoedemaeker and Brookhuis (1998) discussed the potential negative safety effects of ACC based on increased lane position variability and braking delays. Based on these studies, the motivation for this study is as follows: 'Can ADSs, which consider only situations in the vicinity of an equipped vehicle, really contribute to a significant reduction in traffic accidents?' To address this question, this study investigates the interactions between equipped vehicles and unequipped vehicles and evaluates the traffic safety at different MPR levels based on a proposed index to represent the overall rear-end crash risk (RCR) in the traffic steam. Individual vehicle maneuvers should be studied from the perspective of the traffic stream

متن کامل مقاله ← دریافت فوری

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات