SIV-DSS: Smart In-Vehicle Decision Support System for driving at signalized intersections with V2I communication

Xiao-Feng Xie*, Zun-Jing Wang

WIOMAX LLC, PO Box 540, Rockville, MD 20848, United States

ARTICLE INFO

Keywords:
- Signalized intersections
- Indecision zone
- Traffic safety
- Vehicle infrastructure integration
- Red-light running
- In-vehicle decision support system

ABSTRACT

In this paper, we present a Smart In-Vehicle Decision Support System (SIV-DSS) to help making better stop/go decisions in the indecision zone as a vehicle is approaching a signalized intersection. Supported by the Vehicle-to-Infrastructure (V2I) communications, the system integrates and utilizes the information from both vehicle and intersection. The effective decision support models of SIV-DSS are realized with the probabilistic sequential decision making process with the capability of combining a variety of advantages gained from a set of decision rules, where each decision rule is responsible to specific situations for making right decisions even without complete information. The decision rules are either extracted from the existing parametric models of the indecision zone problem, or designed as novel ones based on physical models utilizing the integrated information containing the key inputs from vehicle motion, vehicle-driver characteristics, intersection geometry and topology, signal phase and timings, and the definitions of red-light running (RLR). In SIV-DSS, the generality is reached through physical models utilizing a large number of accurate physical parameters, and the heterogeneity is treated by including a few behavioral parameters in driver characteristics. The performance of SIV-DSS is evaluated with systematic simulation experiments. The results show that the system can not only ensure traffic safety by greatly reducing the RLR probability, but also improve mobility by significantly reducing unnecessary stops at the intersection. Finally, we briefly discuss some relevant aspects and implications for SIV-DSS in practical implementations.

1. Introduction

The driving behavior of vehicles with regard to crossing a signalized intersection during the signal transition period has major impacts on safety and efficiency of transportation. The decision of a driver at the intersection is a binary decision process, i.e., the driver can either stop the vehicle before the stop line or let the vehicle go through the intersection. If a driver makes a decision to go while the situation is a “should-stop”, the vehicle ends up to a red-light running (RLR) or even more severe to a collision. In USA, 771 people were killed and an estimated 137,000 of people were injured in the accidents involving RLR in 2015, according to Insurance Institute for Highway Safety (IIHS) (2016). If a driver makes a decision to stop while the situation is a “should-go”, the vehicle encounters more traffic delay, which not only wastes time and increases fuel consumption as well as emissions, but also more likely causes a rear-end collision. According to National Highway Traffic Safety Administration (NHTSA) (Choi, 2010), about 40% of the total accidents are intersection-related crashes. Similar results have been also shown by big data analysis (Xie and Wang, 2015).

Among all possible factors resulting in the intersection-related crashes, the indecision zone at the intersection is one of the major
In this paper, we present a novel Smart In-Vehicle Decision Support System (SIV-DSS) to help drivers making right stop/go decisions as the vehicle is approaching a signalized intersection. Our effective decision support models (DSM) are realized via the probabilistic sequential decision making process (PS-DMP) (Xie et al., 2014) which combines the advantages obtained from a set of decision rules. With the theory of bounded rationality (Brandstatter et al., 2006; Gigerenzer and Gaissmaier, 2011), each decision rule is (fast and) frugal, which works well on different situations. We extract decision rules from the state-of-the-art models and mechanisms pertinent to the indecision zone problem. We also extend them and design new decision rules to utilize and handle the key inputs from vehicle motion, vehicle-driver characteristics, signal timings, intersection geometry and topology, and the definitions of RLR. Thus, SIV-DSS is able to explore in a much larger variable space of physical and behavior parameters than the previous methods, to support individualized decisions for different drivers and robust indecision zone protection at different intersections. The performance of the proposed system is evaluated with systematic simulation experiments. The results indicate that for vehicles approaching an intersection, our integrated in-vehicle decision support system can not only enhance the safety through significantly reducing RLR probability, but also improve the efficiency through reducing unnecessary stops.

2. Problem description

Fig. 1 illustrates a generic situation when a vehicle moves on a road approaching toward a signalized intersection, where some information is known about the intersection and associated infrastructure. The intersection geometry and topology (i.e. MAP) contains the location information of the stop line and the clear line for each entry movement, etc. The intersection width $W$ is the distance between the stop line and the clear line. On the Signal Phase and Timing (SPaT) of the traffic light, let $t$ be the remaining green time, $T_{cd}$ be the green countdown time, $Y$ represent the yellow change interval, and $R$ represent the red clearance interval. The road information contains the speed limit $V$, the grade $G$, and other road conditions on the approach road. Each vehicle follows a specific definition of red-light running (RLR) according to the local law, as crossing the intersection. On the vehicle, let $v$ be the moving speed, $x$ denote the distance of the vehicle from the stop line, and $L$ be the length of the vehicle. Each vehicle can
دریافت فوری متن کامل مقاله

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