ABSTRACT

Current intersection-control systems lack one important feature: They are unaware of the different valuations of reduced waiting time of the drivers. Drivers with high valuations may be willing to pay to be prioritized at intersections. In this chapter, the authors describe an agent-based valuation-aware intelligent traffic-control system for road intersections which increases the overall driver satisfaction. It combines valuation-aware intersection-control mechanisms with sophisticated driver-assistance features, subsequently referred to as adaptive cruise and crossing control (A3C). Driver-assistance agents and intersection agents negotiate so-called time slots to cross the intersection. The driver-assistance agent adapts the speed of the vehicle in line with the time slot obtained. Various obstacles are in the way of realizing such a system and making it operational. The authors discuss these challenges and present ideas for solutions. They examine the intersection-control and the driver-assistance perspective of the intelligent traffic-control system. After a brief evaluation, they finally describe application scenarios where agent-based valuation-aware intersection control may become operational in the near future.
INTRODUCTION

The growing need for mobility makes it more difficult for cities to cope with the increasing number of vehicles and to provide the necessary infrastructure. Optimizing the use of existing traffic resources may be much cheaper than building new ones. Thus, cities introduce more sophisticated intelligent traffic-control (ITC) systems for road intersections. Current ITC systems do not take the driver valuations of reduced waiting time into account. This valuation may be different for each driver and for trip types, e.g., a driver who is in danger of missing a flight may have a higher valuation than one on a weekend trip. Taking these valuations into account can increase the overall driver satisfaction.

The ongoing progress in vehicle technology allows for more sophisticated driver-assistance systems. The automotive industry currently offers various driver-assistance systems which increase safety or comfort of drivers and passengers. A new application area for such systems is intersection control, i.e., traffic control at road intersections. The more information is available to an ITC system, the better it can deal with the current traffic. While current ITC systems for intersection control are already context-aware, i.e., they rely on historic traffic data or on actual traffic data collected with stationary sensor technology, driver-assistance systems may provide access to information which stationary sensors cannot collect. The driver valuation of reduced waiting time is a prominent example. We call systems which also consider this valuation of the drivers valuation-aware.

This chapter describes a valuation-aware ITC system for road intersections. Such a system requires negotiation between vehicles and infrastructure. To avoid unnecessary distraction of the drivers, we propose to use autonomous software agents for the negotiation. Next, the system should be able to adapt to changes in the traffic in real time. Further, it must be more effective than existing traffic-control systems. The ITC system combines valuation-aware intersection-control mechanisms with sophisticated driver-assistance features: Driver-assistance systems play a central role for valuation-aware intersection control. Using valuation-aware mechanisms, driver-assistance systems which are located in vehicles negotiate the right to cross an intersection with the intersection-control unit located at the intersection. The driver-assistance systems report the valuation of reduced waiting time of their drivers. The intersection-control unit assigns time slots to the road users taking the valuations into account. After having been notified about its time slot the driver-assistance system knows when to cross the intersection. Thus, it recommends an appropriate speed to the driver. If the driver-assistance system can also adapt the speed autonomously, we can extend the functionality of an ACC system with crossing control features. This means that the driver-assistance system does not only adapt the speed autonomously to keep a time gap to preceding vehicles, but also to reach the intersection in time. We call this adaptive cruise and crossing control (A3C). We examine the two perspectives of the system, the intersection-control perspective, i.e., valuation-aware intersection-control mechanisms, and the driver-assistance perspective, i.e., the A3C system.

The outline of this chapter is as follows: We discuss other approaches for intersection control in Section “Background”. Section “Definitions” features some definitions. Various obstacles are in the way of realizing such a system and making it operational. We provide a survey of the various challenges related to traffic engineering, information technology, economy, road users, and law in Section “Challenges”. Since our research project now is in its third year, and we have had interaction with researchers from other disciplines, our survey addresses all severe issues which have been raised. Sections “Intersection-Control Perspective” and “Driver-Assistance Perspective” examine the two perspectives of our system.