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Control strategies of traffic signal timing transition for emergency vehicle preemption

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ABSTRACT

Emergency vehicle (EV) operation saves lives and reduces property damage. This paper reports two new control strategies for EV signal pre-emption (EVSP) that reduce the response time and minimize the impact of EV operation on general traffic. A real-time control strategy is developed that enables signal transitioning from normal operation to EVSP (transition 1) so that the approaching EV can cross the intersection safely at its operating speed and also the impact of the EVSP on general traffic is decreased. The green time that is not required for the EV is dynamically allotted to the traffic on the cross road by taking into account the prevailing traffic condition at the intersection and the state of signal indication. The second control strategy, implemented by an optimal control algorithm, is used for the signal transitioning from the EVSP back to normal operation (transition 2). A two-phase algorithm, consisting of a relaxation method and a stepwise search strategy, is adopted to overcome the difficulty in solving the optimal control model, which results from the interrelationship between successive signal sequences. Software was developed in the MATLAB environment for simulations of the EVSP process under different signal timing transitioning control strategies. Results indicate that the real-time control and the optimal control strategies and their associated methods perform better than the commonly used existing approaches. It is also demonstrated that the two control strategies are applicable to different traffic conditions up to and slightly over-saturated level, and can be used to deal with a single EVSP occurrence as well as multiple EVSP occurrences.

1. Introduction

During emergency operation, it is a challenge to ensure safe passage of an emergency vehicle (EV) or multiple EVs and at the same time to maintain safe and smooth traffic flow in the road network. Generally, from almost daily small incidents to major disasters, police, fire fighters and ambulances are required to reach the emergency scene for initial lifesaving and scene stabilization. Frequently, existing congested traffic conditions make it difficult for EVs to arrive at the scene in a quick and safe manner. On the other hand, it is not uncommon that EV operations cause congestion and sometimes become involved in incidents and accidents (US DOT, 2002; TRB, 2002).

From the perspective of traffic control, EV operations require attention at the network level as well as at the intersection level. The task at the network level is to determine the quickest route from the origin of an EV to its destination, so that the EV can reach the scene at the earliest possible time along the selected route. The requirement at the intersection level is to ensure that the EV can pass in a quick and safe manner.

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