Design and Multiobjective Optimization of Efficient Vehicle Management Framework for Cyber-Physical Intelligent Transportation Systems

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1 Introduction

Cyber-Physical systems (CPS) consists of a collection of computing devices communicating with one another and interacting with the physical world via sensors and actuators in a feedback loop. In this paper, our aim is to propose an efficient vehicle management (EVM) for cyber-physical ITS. We concern about the driver's preference (e.g., the shortest traveling time to reach a destination) and the safety of roadway (e.g., accident risk).

Many research interests focus on the CPS-based transportation systems these days. Most of the researches are mainly studied on the optimal control of vehicle for the collision prevention. However, a driver is also an essential factor that might affect the system, in which it should be taken into the consideration. For instance, the driver wants to reach a destination in the shortest time would tend to drive the vehicle in the fastest speed, in which this can lead to the higher risk of accident. Thereby, this paper applies a multiobjective optimization (MOO) method into the cyber-phsyical ITS and studies the optimal decision in between the shortest traveling time and the probability of accident risk.

2 Efficient Vehicle Management Framework

Fig. 1 shows the general framework, in which the future vehicle is able to communicate with other vehicle and roadside infrastructure by exchanging information such as speed and distance between the vehicles, number of vehicles, and status of traffic light.

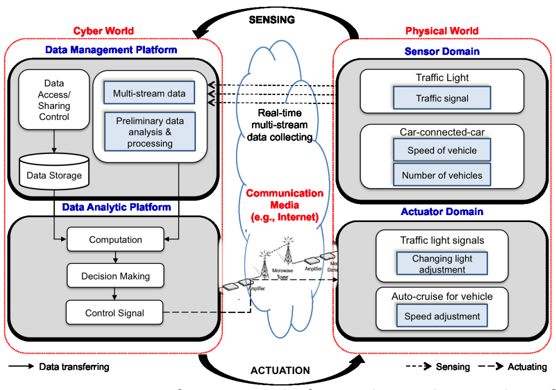

Figure 1: EVM framework for cyber-physical ITS

In this paper, we consider the tradeoff in between the shortest traveling time and the probability of accident risk. Thus, two models are used: (1) speed adjustment model and (2) vehicle collision model. In the speed adjustment model, we assume that the vehicle is embedded with sensors, which are able to detect the dedicated speed limit of a roadway. According to the driving regulation, s vehicle will travel in the maximum speed limit in order to achieve the least time from a starting point to a destination. In the vehicle collision model, the vehicle is able to communicate and collect the information of neighboring vehicles. The information including the speed and distance of the neighboring vehicles. This model focuses on the probability of intersection collision.

The goal of MOO method is to find an optimal decision to fulfill both the objective functions, that minimize the shortest traveling time and the probability of accident risk simultaneously. The objective function of the shortest traveling time, T_{DD} is

$$min \quad T_{DD} = \sum_{i=1}^{V} t_{DD}^{i} \tag{1}$$

V is the number of vehicles and t_{DD}^{i} is the shortest traveling time of ith vehicle. The objective function of the probability of accident risk, P_C [1] of an intersection collision in between two vehicles is

$$min \quad P_C = \int_{T_B}\int_{T_A} p(T_A, T_B) coll(T_A, T_B) dT_A dT_B \tag{2}$$

The function $p(T_A, T_B)$ gives the probability of two vehicles of driver behavior. The function $coll(T_A, T_B)$ is a collision happens for two vehicles.

3 Concluding Remarks

This paper expects a result of optimal decision for the tradeoff in between the shortest traveling time and the lowest probability of two vehicles that might be collided.

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References

[1] S. Joerer, B. Bloessl, and C. Sommer, "*A vehicular networking perspective on estimating vehicle collision probability at intersections*," IEEE Trans. on Veh. Technol., vol. 63, no. 4, May 2014.