Model Study for Intelligent Transportation System with Big Data

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Abstract

The increasing development of big data technology has brought great opportunities and challenges to innovation of complex system such as Intelligent Transportation System (ITS), especially in the method of big data driven modelling. This paper focused on analyzing the feasibility of model study based on noisy trajectory data collected by cell phone for ITS. A method of real-time modelling based on trajectory data is proposed and specific experiment is designed for analysis. An improved GHR car-following model is accepted in this paper for parameters calibration by Least-square method. Sensitivity analysis and cross-calculation are performed to validate if the modelling process is reliable and robust enough. Research results show practicable of noisy data in data-driven modeling. The results of this paper show feasibility of using trajectory data from cell phone for dynamic modeling for Intelligent Transportation System.

Keywords: Intelligent Transportation System; big data; data-driven modeling; GHR model.

1. Introduction

In recent years, big data related technologies developed greatly and rapidly, which provides new ideas and tools for smart management and decision-making \cite{1}. Data mining is widely applied in model study for simulation of complex systems and decision-making support. Big data recorded almost all the activities of systems which leads to possibility of system modelling, predicting and optimizing. However, even if big data may provide information needed in modelling process, it is not completely credible for model development based on data directly due to data noises which is common issues for big data. One example is the Google flu predicting. Google announced flu predicting result based on big data, which is quite good in the first year but proved to be incorrect in the following years \cite{2}. Recently, methods data-model combination or cooperation has become a highlight in the field of system simulation. Warren Comwall introduced a concept of “mixed model”, which stress the importance of combining data and model to achieve better prediction \cite{3}. In the field of traffic management, with developing of Intelligent
Transportation System (ITS) for which information and communication technologies are widely applied, traffic big data has been established including infrastructure, vehicles and driver behaviors with GPS, CCTV, detectors, IC cards, cell phones and other carry on devices. Rapid and dynamic modelling with big data may provide better simulation abilities for ITS.

Driver behavior modelling which describes the characters of movement of vehicles is believed to be a basis of ITS management, and big data play an important role in the modelling process since big data carries much information that reflects inter-driver and intra-driver variability. In the past several decades, many researchers tried to calibrate different traffic models with big traffic data. Ozaki analyzed a car-following model using the data from a video film of continuous traffic flow\([4]\). Arne Kesting calibrated IDM and VDM models by radar sensor collecting the relatives speed and distance\([5]\). For traffic data collected by different devices, trajectories data collected by cell phone and GPS are easily to acquired. Martic built a multiple combined model describing the characters of human dynamics to predict the movement of individuals based on the GPS data from 136 volunteers\([6]\). Bazzani reveals the travel distribution of private cars using GPS data and discovers that trip distance obeys exponential distribution, and the travel time obeys the compound power-law distribution\([7]\). In this paper, car-following model calibration is studied with trajectory data collected by cell phones, which may has data noises, to discuss the feasibility of dynamic modeling with low quality big data for ITS.

2. Experiment design

For the last two decades, the advent of big data brings great opportunities and challenges to theoretical research and practical application for the development of Intelligent Transportation System. Qi Shi and Mohamed Abdel-Aty believed that traffic big data may contribute in congestion measurement, real-time crash prediction and rear-end crash\([8]\). In addition, traffic trajectory big data collected by Global Positioning Systems and cell phones also plays an important role in traffic modelling and simulation even though there is not yet a common acknowledgement whether data from cell phones would be capable for accurate modelling. In this paper, experimental study is performed to find possibility of modelling with traffic big data by cell phones.

A straight four-lane roadway with approximately 500m in length and 14m in width is selected as experimental road. Position data of two experimental cars were acquired with cell phones that are place in each car. Position data is collected at 1s intervals. The two experimental cars run on the road with following rules:

- No overtaking or lane-changing. This is because car-following models applies only to the situation that one car keeps following the front car on the same lane.
- The mean gross headway distance is smaller than 50m, as it is believed driving behavior of the following car’s driver is determined by his sensitiveness to the stimulation from the front car. If the headway distance is too large, there will be no interaction\([9]\).
- Leader car’s driving is totally under control to do some specific actions such as sudden brake or accelerating and this is to test the ‘following’ character of the follower car.
- Follower car keeps driving without any commands.

Such rules are conducted to make sure the relationship of these two cars is analogous to a “leader-follower” combination. Since there is not a clear definition of the location precision for cell phone, specific GPS receiver is also fixed in each car acting as a data references. Position precision of GPS is supposed to be within one decimeter with a calculus of finite difference.

Both cell phone and GPS directly provide longitude and latitude of the vehicle. The longitude and latitude coordinates in geodetic coordinate system (B, L) are firstly transformed to plan-metric rectangular coordinates (X, Y) by Gauss projection. Vehicle velocity is derived in the x-direction and y-direction (first derivative of x and y trajectories) and acceleration (second derivative) can be acquired by the same method. Headway distance is derived by using equation of Euclidian geometric distance. Necessary data filtering is done after all velocity, acceleration and headway distance data is calculated.
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