Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 3 (2014) 51 – 59

Transportation Research Procedia

www.elsevier.com/locate/procedia

17th Meeting of the EURO Working Group on Transportation, EWGT2014, 2-4 July 2014, Sevilla, Spain

Analysis of the Driving Behaviour at Weaving Section Using Multiple Traffic Surveillance Data

Andyka Kusuma*, Ronghui Liu, Charisma Choudhury, Francis Montgomery

Institute for Transport Studies, 34-40University Road,Leeds LS2 9JT, United Kingdom

Abstract

Weaving sections are formed when a merge area is closely followed by a diverging area, or when an entry slip road is closely followed by an exit slip road and the two are joined by an auxiliary lane. Driving in the weaving section involves complex car-following and lane-changing interactions. This paper presents two empirical data collection and data extraction processes based on traffic surveillance camera and loop detector measurements. It examines the quality of the extracted data, and highlights the possible sources of measurement errors considering that the speed and acceleration are varied significantly. This paper proposes locally weighted regression method for data cleaning and presents example results to demonstrate the method by combining the two data sources. The study succeeds in identifying some key driving characteristics of vehicles in the weaving section. We found that 25.25% of the weaving movements took place in the first 50-100 meters from the point of merge. Around 30% of the total traffic involved in one lane-changing movement. Meanwhile, the transit time for the driver with more than one lane-changing is 4.09 sec in average. The appearance of auxiliary lane in the weaving section provides further opportunity to delay the lane-changing, which affects the traffic performance.

Selection and peer-review under responsibility of the Scientific Committee of EWGT2014

Keywords: Driving behaviour; Weaving section; Traffic survaillance data

1. Introduction

Driving behaviour, which describes the drivers' intentions behind the maneuvers from the current position towards a target position, significantly affects the traffic performance. These effects are more pronounced in multilane facilities where each driver has a preference to maintain his/her current lane or shift to the target lane (Bonsall et al., 2005).

Driving movements are typically motivated by expectations of one/more gains or advantages from the ambient traffic i.e. increasing speed, avoiding delay, and overtaking the lead vehicle. Moreover, the movement can be mandatory in order to comply with a traffic regulation, avoiding an incident in the current lane, or to take an exit or make a turn to follow the path-plan (Laval and Daganzo, 2006).

Weaving is defined as the crossing of two or more traffic streams traveling in the same direction along a significant length of

* Corresponding author. Tel.: +44-113-34-37325; fax: +44-113-343-5334
E-mail address: tsak@leeds.ac.uk

Selection and peer-review under responsibility of the Scientific Committee of EWGT2014
doi:10.1016/j.trpro.2014.10.090

the highway without the aid of traffic control devices. Eventually, in a motorway weaving section, the lane-changing appears in high number especially closer to the end of the merging and diverging points where the drivers expect to merge or diverge from the main traffic. Thus, the lane-changing drivers have to critically observe and evaluate the traffic condition both in the current and the target lane. They pursue continuously for a safest condition to precede the lane-changing movement. The movement in motorway section is critical since the distance between the merging and diverging area are relatively short (2,000-3,000 metres according to the Design Manual for Roads and Bridges (DMRB) (2006)).

This paper analyses the characteristics of driving behaviour in a motorway weaving section two sources of traffic surveillance data: an extraction from a direct video recording and the Management Incident Data Analysis (MIDAS) loop detector data. Individual vehicles trajectories are extracted from a 5min video recording, using the Semi-Automatic Video Analysis (SAVA) software (Archer, 2003). MIDAS provides traffic flow, speed and headway data (averaged over 1 minute) from loop detectors. The observation is taken at the M1 motorway network between Junctions 41 and 43, which is near Leeds, United Kingdom.

2. Background

Vehicle interactions, in terms of their car-following and lane-changing behaviour, have a significant impact on motorway traffic performance. These interactions are contributing to traffic flow breakdown and capacity drop in the main carriageway and the entry slip road (Cassidy & Rudjanakanoknad, 2005; Wang, Liu, & Montgomery, 2005a, 2005b). The traffic interaction on a motorway weaving section is even more complex because the lane-changing and weaving interactions have to occur at a relative short distance between an entry and exit split roads.

Number of factors affects the driving behaviours; road geometric, available gap and traffic condition both in the current and the target lane. Those factors are significant input for the microscopic modelling. Moreover, in this regards, the drivers may seek for a condition which gives them the highest utility. Depending on the particular situation, a driver has his/her own preference to evaluate and decide either to stay in the current lane or make a lane-change to left/right (Ahmed, Ben-Akiva, Koutsopoulos, & Mishalani, 1996; Choudurry, 2007; Toledo, Choudhury, & Ben-Akiva, 2005).

Therefore, to capture the driving behaviour in weaving sections in microscopic level, this paper proposes the traffic surveillance camera and the loop detector data as the main source. The aim of the traffic surveillance technique is to trace the vehicle location and the traffic condition around the observed vehicle at the specific time (t) sec. Combining the traffic surveillance camera and loop detector data sources thus allows us to use the strengths of both data sets.

Traffic surveillance is a method in capturing the driving behaviour at the observation location. The video data provides observed driving behaviour in high level of details (Al-Jameel, 2011; Choudhury & Ben-Akiva, 2008; Koutsopoulos & Farah, 2012; Kusuma & Koutsopoulos, 2011; Toledo et al., 2005). In fact, the video observation produces number measurement error due to imaging processing and obstruction. Therefore, the locally regression method is introduced to increase the data accuracy level (Punzo, Borzacchiello, & Ciuffo, 2011; Toledo, Koutsopoulos, & Ahmed, 2007). More details of the locally regression will be discussed in the section 3.2.

In the UK, the Highways authority records and stores the loop detectors data into a system which is known as MIDAS. It records and stores the loop detectors data at the specific location. It records the basic traffic data such as traffic volume, time speed, level of occupancy, and headway for each lane. MIDAS data has been used in a wide range in order to capture the traffic characteristic and driving behaviour on a specific motorway network

Wang (2006) used both the traffic surveillance and MIDAS data to investigate the driving behaviour in the merging motorway section. The video observation showed that most of the lane-changing occurs at the first available gap. In the other words, the lane-changing occurs at the upstream traffic where the main traffic and entry-slip road traffic meet at the end of the taper marking. The length of the auxiliary lanes in merging area length affects the merging behaviour. In fact, a longer auxiliary lane leads the lane-changing drivers to become conservative in order to seek for larger gap rather than accept the first gap. The average speed between the lanes, where most of the lane changing occurs, is relatively similar.

Al-Jameel (2011) observed the effect of lane-changing in a motorway weaving section. To do so, the study applied a simulation the traffic surveillance and MIDAS loop detector. It showed that the average speed of the lane-changing drivers, when it starts the lane-changing movement, is lower compare to the lead vehicle at the target lane. Then, the lane-changing vehicle speed increased slightly during the lane-changing. This study found that the lane-changing drivers prefer to precede the lane-changing at the end of the taper at the merging area.

The current research extends the usage of traffic surveillance method and MIDAS to capture the lane-changing characteristics at the weaving section. This research proposes the traffic surveillance camera to extract the vehicle trajectory and the movement characteristic of each vehicle (i.e. acceleration, lane-changing location). The study realise that the video observation there is a significant error in the video extraction process. Moreover, the error is clearly represented in speed and acceleration analysis. The study adopts the locally weighted regression method to relax the error which this approach has not been used in the two previous researches.

MIDAS provides the ambient traffic condition at the observation location at macroscopic level. It provides the base line dataset for the validation process. In fact, this paper validates the observed speed of the traffic surveillance extraction result with MIDAS. More details regarding the data extraction and validation process will be discussed in the next section.