Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 27 (2017) 672–679

Transportation Research Procedia

www.elsevier.com/locate/procedia

20th EURO Working Group on Transportation Meeting, EWGT 2017, 4-6 September 2017, Budapest, Hungary

Video Based Data Collection Process for Geometric Design Consistency Evaluation of Four-Lane Median Divided Horizontal Curves

Gourab Sil[a]*, Avijit Maji[b]

[a,b]*Indian Institute of Technology Bombay, Powai, Mumbai: 400076, India*

Abstract

Free flowing vehicle speed data are essential in the geometric design consistency evaluation of highways. Video based data acquisition technique can be used for the purpose. Further, in four-lane median divided highways, the vehicle needs to be monitored for the presence of other vehicles in the adjacent lane. The video log helps in vehicle tracking, vehicle classification, identification and monitoring free flow conditions along a stretch. Now, the vehicle speed is estimated from the travel time to cross known trap length. The accuracy of the speed data depends on the frame rate of the camera and trap length. The maximum possible error in estimating the travel time to cross known trap length is found to be one frame and its effect on vehicle speed estimation decreases with increase in trap length. However, observation (parallax) error increases with trap length. So it needs optimization. A field study is conducted with varying trap length to come up with the optimum values. The findings show that an optimal value of trap length is 15m. Also a video based data acquisition setup has been proposed to track free flowing vehicle. Finally, data set from video recording technique have been compared with standard data set. Results show that the speed measurements based on the proposed video based method are not statistically different from the standardized equipment.

Peer-review under responsibility of the scientific committee of the 20th EURO Working Group on Transportation Meeting.

Keywords: Video based speed data; Horizontal curve; Data collection setup; Free flow condition; Optimization.

1. Introduction

Different countries (Switzerland, Canada, United Kingdom, Germany, France and Australia) have adopted various geometric consistency evaluation techniques in the design process (Gibreel, 1999). Some of these techniques require development of speed profile along the alignment. It can be obtained by tracking the free flowing vehicles within a study area (Misaghi and Hassan, 2005; McFadden and Elefteriadou, 2000). Researchers have adopted global positioning system (GPS) fitted vehicles and roadside laser detectors, sensors or video camera for the purpose (Fitzsimmons *et al*., 2012*;* Hasim *et al.,* 2016*;* Camacho-Torregrosa *et al*., 2013; Misaghi and Hassan, 2005).

* Corresponding author. Tel.: +91-9038152961
E-mail address: silgourab@gmail.com

2352-1465
Peer-review under responsibility of the scientific committee of the 20th EURO Working Group on Transportation Meeting.
10.1016/j.trpro.2017.12.157

However, vehicle fitted GPS can make drivers over sensitive about vehicle speed (Nama *et al*., 2016 a). Data collected using roadside laser detectors and sensors may not be efficient in identifying vehicle categories accurately. Moreover, in these techniques, passing movement of vehicles cannot be recognised. Therefore, video based data collection technique can be used to overcome these drawbacks. Now, researchers have used video recording technique for speed data collection (Boora and Ghosh, 2016; Fitzsimmons *et al*., 2012; Dey *et al*., 2006; Jacob and Anjaneyulu, 2012; Sil *et al*., In Press). They have used different trap lengths varying between 10m and 60m to estimate spot speed (Boora and Ghosh, 2016; Fitzsimmons *et al*., 2013; Dey *et al*., 2006; Jacob and Anjaneyulu, 2012; Sil *et al*., In Press). In this method, the accuracy of spot speed depends on: i) frame error and ii) observation error. The information lost between the two frames of the video while a subject vehicle crosses the boundary lines of a trap is indicated as frame error. On the other hand, parallax in identification of a subject vehicle crossing the boundary lines of a trap is termed as observation error. Increase in vehicle speed and decrease in trap length increases frame error. Whereas, the observation error increases with increase in trap length. So, selecting suitable trap length requires optimization of the two errors.

Some of the key assumptions of car following theory are a) vehicles travel in the centre of the lane, and b) a vehicle is influenced directly by only one leading vehicle. However, in the field, not all vehicles travel along the centre of a lane. In lane-based-driving, vehicles are positioned as close as possible to the centre of the lane (Gunay, 2003, 2007, 2009). However, in developing countries (Mathew *et al*., 2013; Maurya, 2011; Sil *et al*., In Press; Nama *et al*., 2016 b) and semi-urban and urban areas of developed countries true lane-based-driving cease to exist (Gunay, 2003, 2007, 2009). This weak lane discipline may be attributed to inadequate lane markings, poor visibility, inadequate lane width, poor road surface and deterioration in perfect driving attitudes (Gunay, 2003, 2007; Khan and Maini, 1999). In these situations, following vehicles are affected by leader vehicles in adjacent lanes (Mathew *et al*., 2013; Gunay, 2003, 2007; Maurya, 2011; Sil *et al*., In Press). Further, in multilane divided highway, vehicles involved in passing movement (PM) may affect each other's speed (Rawson, 2015). In summary, vehicles in adjacent lane can influence the subject vehicle.

The primary objectives of this study are:

a. Estimate an optimum trap length to minimize frame and observation errors;
b. Develop free flow criteria for four-lane divided highway; and
c. Evaluate accuracy of video based vehicle speed estimation technique.

2. Optimum trap length

Frame and observation errors affect accuracy of vehicle speed estimation in "video recording and trap length" method. Now, frame error depends on camera speed (represented as frame per second, FPS) and observation error on camera resolution and solid angle of view. In this study, frame error is estimated from theoretical derivations and observation error from field observations. The following two sub-sections describe the estimation of frame and observation errors.

2.1. Frame error

Vehicle speed is measured from video recordings by noting down the time of vehicle's front wheel touching the two boundary lines of a trap. The recorded video is played frame by frame for this purpose and frames in which front wheel touches the boundary lines are identified. There are two possibilities of vehicle's wheel positions: (a) wheel exactly "on the line" (E_{11} *or* E_{12} in Figure 1) and (b) just "before the line" or "after the line" (E_{21} *or* E_{22} in Figure 1). Availability of frames with wheel position exactly "on the line" is uncertain and possibility (b) introduces an error in speed measurement. Now, possibility (b) has two situations, "before the line" and "after the line". Speed measurement considering wheel exactly "on the first line" (E_{11}) and "before the second line" (E_{22}) (i.e., when "on the second line" frame is not available) would induce positive error, with estimated speed higher than the actual speed. Similarly, considering "before the first line" (E_{21}) and "on the second line" (E_{12}) induces negative error, with estimated speed slower than the actual speed. Analysing all possibilities from Figure 1, it can be concluded that the maximum error in speed estimation depends on the maximum possible value of "X". Where, "X" is the error in distance. Now, careful observations would lead this error within one frame. Vehicle speed for trap length upto 60m is considered as spot speed (Boora and Ghosh, 2016; Fitzsimmons *et al*., 2012; Dey *et al*., 2006; Jacob and Anjaneyulu, 2012; Sil *et al*., In Press). Therefore, in frame error estimation, it is assumed that "*Vehicles are running at constant speed (V) within the trap*". Now, from Figure 1, the frame error can be estimated as: