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Modelling freeway weaving manoeuvre

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Abstract

This paper focuses on modeling the acceleration-deceleration behavior of drivers during freeway weaving manoeuvres, under heavy traffic conditions. Data capturing a wide range of microscopic information were collected using video-recording and image processing techniques. The data was collected at two weaving sections on urban freeways in Tokyo and Melbourne. A theoretical framework for modeling weaving driver acceleration-deceleration behavior is presented. The collected data are used to calibrate the proposed model. A particular feature of the proposed model is that it captures the acceleration-deceleration behavior of drivers during the entire process of weaving manoeuvre. The results indicate that on average a 0.72 sec time gap exists before weaving drivers respond to stimuli. It is found that the surrounding freeway vehicles significantly affect the weaving vehicle acceleration behavior.

1. Introduction

Weaving sections are those areas of a highway where two or more adjacent traffic streams, temporarily merge and travel in the same general direction, before moving into another set of adjacent traffic streams. Acceleration gap acceptance and lane changing throughout weaving processes constitutes an important aspect of freeway traffic operations and weaving section geometric design. Traffic competing for space in the weaving section will influence traffic flow in the upstream and downstream freeway lanes at the start and end of the weaving section. A driver entering a weaving section and who intends to move from its current lane to the target/adjacent lane, must make a series of decisions and carry out control tasks, within the driver's capability to process the roadway and traffic information and translate these into speed and position control responses (see Figure 1). It is considered that if there is an available gap, the gap between two vehicles traveling in the adjacent lane, and it is acceptable, the weaving driver accelerates and moves directly into the available gap. If no gap is available the driver may accelerate to create a lane changing opportunity, or decelerate and wait for a later gap.

Weaving vehicle acceleration-deceleration characteristics are essential components in all microscopic simulation models designed for simulating the freeway weaving sections. Several traffic simulation tools have been developed recently, such as AVENUE (2007), PARAMICS (2007), AIMSUN (2006), CORSIM (2003), MITSIM (Yang et al. 2000), VISSIM (2007).

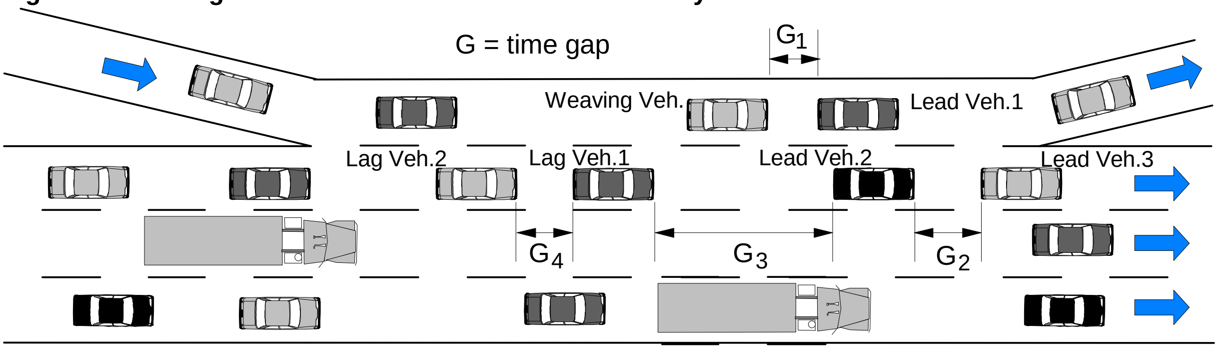
Nevertheless, several major problems including computational performance, the accuracy of models in representing the traffic flow, and the difficulty of integration with advanced traffic management and traffic information systems has been reported in the literature (Skabardonis and May, 1998). Weaving vehicle acceleration characteristics in the vicinity of the weaving section is a fundamental component of all network micro-simulation models particularly those which are designed for simulating freeway weaving sections. The difficulties of modeling active bottleneck in weaving areas with the existing simulation models are well acknowledged (Prevedouros and Wang 1999, Skabardonis 2002, Gomes et al. 2004). Gomes et al. reported that VISSIM is unable to model weaving section under heavy traffic flows. Similar problems have been reported by AIMSUN, CORSIM and PARAMICS users. Sarvi (2000) reported several major problems such as a very unrealistic driver behavior, long queue and underestimated maximum throughput while using PARAMICS to model an active weaving bottleneck.

Microscopic simulations may be capable of modeling freeway weaving sections under low to moderate traffic flows when there are insignificant interactions between weaving and freeway drivers. In these situations, most of the available micro-simulation models simply use one of several simplistic assumptions including constant speed for weaving vehicles, constant acceleration rates, maximum waiting time, or conventional follow the leader car-following models (Zarean et al. 1988, Chang et al 1991, Nakamura et al. 1991, Jian et al. 2005). However, the interactions between the weaving and the adjacent freeway drivers become substantially more important when traffic flow is close to the capacity. The complex acceleration characteristics of weaving drivers and the significant interactions of the weaving and freeway vehicles in the adjacent lane are believed to play an important role in modeling freeway weaving sections. The major limitation of existing microscopic simulation models is that they employ a global car following and lane changing model to capture acceleration characteristics of drivers in all driving situations (e.g. utilizing the same car following model to model driving in a basic freeway section and driving in the vicinity of a weaving or merging section (Panawi and Dia 2005)).

Few studies in the literature dealt with vehicle interactions in detail (Kojima et al. 1995, Bham and Benkohal 2004, Hidas 2005, Sarvi and Kuwahara 2007, Toledo et.al 2009). These researches predominantly focused on developing methods for modeling the interactions between vehicles during lane changing manoeuvres. This concept is based on a simple assumption that a weaving driver will only adjust his speed in accordance to his immediate leader and follower vehicles in the adjacent lane. The dynamic interactions between the weaving vehicle and the further surrounding vehicles (e.g. Lead veh. 3 and Lag Veh. 2 in Figure 1) are not considered in these models. These interactions would have an important impact on the acceleration-deceleration profile of the weaving vehicles and hence, affect the traffic characteristics of the weaving section. The changes in behavior of the adjacent vehicles (non-weaving vehicles) due to the influence of the weaving vehicles are also not considered in these models. Additionally, all these models are predominantly developed for low to moderate traffic volumes thus, are not suitable to model heavy traffic conditions.

In contrast, this work presents the details of the complex interactions of vehicles at the time of freeway weaving manoeuvre and presents a thorough methodology that could be used to model weaving vehicle acceleration-deceleration behavior under heavy traffic flows. For this purpose, sets of data capturing a wide range of microscopic information were collected using video-recording and image processing techniques. The weaving vehicle's position in comparison to surrounding vehicles (e.g. freeway leader and lag vehicles) was analyzed. Additionally, weaving positions with respect to weaving vehicle speed as well as relative speed and time gap between a weaving vehicle and its corresponding leader and lag vehicles were also examined. The methodology presented in this work uses the stimuli-response psychophysical concept as a basic rule to model the weaving driver's acceleration-deceleration behavior (Leutzbach and Widemann 1986). The findings of this work may be utilized to upgrade the weaving vehicle acceleration component of existing microscopic freeway simulation models.

Figure 1. Weaving manoeuvre notation used in this study.



2. Data

In order to study the driving behavior during the weaving manoeuvre under heavy traffic conditions (weaving section is an active bottleneck and there is no exogenous flow restriction from downstream), traffic surveys were performed at Hakozaki and Southbank weaving sections in Tokyo and Melbourne respectively. Hakozaki weaving sections is 500 meter long section with no auxiliary lane and Southbank is 900 meter long section with one auxiliary lane. Traffic flow was recorded using several video cameras mounted on the top of the buildings in the vicinity of the weaving sections. A total of 6 hours of data were recorded at both sites. The tapes were first reviewed and a number of weaving manoeuvres identified. Each manoeuvre was analyzed in microscopic detail. The position and speed of each vehicle involved in the weaving manoeuvre were identified at 0.15 seconds interval using a frame by frame image processing technique. Through this microscopic analysis, time-series data of vehicle position, velocities, and accelerations were stored for 130 weaving manoeuvres (70 manoeuvres at Southbank and 60 manoeuvres at Hakozaki were analyzed). In this is study only 130 manoeuvres were extracted due to funding limits.

From the trajectory data, front/rear spacing, relative speeds, accelerations of weaving and adjacent vehicles were analyzed. Fig. 3 shows the positions of the lead vehicle 2 and lag vehicle 1 relative to the subject vehicle (i.e. the weaving vehicle in Figure 1) during a weaving manoeuvre.
Since, weaving vehicles not only consider spacing or relative speeds but also the interrelationship among these variables, when they perform a weaving manoeuvre these variables are closely related to each other. Further, weaving manoeuvres and consequent lane changing may occur at very short space gaps when the difference in speeds is large.

3. Freeway weaving process analysis

The detailed analysis, described in the following section, shows that the behavior of a weaving driver while moving along the weaving section is generally influenced by his corresponding five surrounding vehicles, as illustrated in Figure 1 (further discussion is also given in the next section). No significant interactions in terms of acceleration-deceleration or gap searching and acceptance between the weaving vehicle and vehicles located in front of the Lead Veh. 3 or behind the Lag Veh. 2 were observed in the 130 weaving manoeuvres studied in this work. Under free flow conditions, a weaving driver has more options and may look towards two vehicles either in front or behind to find acceptable gaps in the adjacent lane. However, in heavy traffic situations fewer acceleration-deceleration opportunities limit the gap searching behavior. The following section examines the relative speed and spacing between the weaving vehicles and the surrounding freeway leader and lag vehicles based on 130 weaving manoeuvres studied in this work. Also a summary of statistical *t* tests is given in Table 1.

3.1. Relative speed between weaving vehicles and its corresponding freeway leader vehicles

Figures 2-a , 2-b, and 2c show the data between the weaving vehicle acceleration and its relative speed for weaving vehicles and freeway leader vehicles (Lead Veh. 1, Lead Veh. 2, and Lead Veh. 3 in Figure 1). The relative speed measured with respect to the freeway leader vehicles is defined as follows:

Relative Speed (Vfleadweave) = freeway lead vehicle speed-weaving vehicle speed

Relative speed is one of the most important variables that affect the freeway weaving behavior. Based on Figures 2 when the speed of a weaving vehicle is lower than its freeway leader vehicles traveling either in the same lane or in the adjacent lane, a positive relative speed, the weaving driver will accelerate and tries to minimize relative spacing. However, if the speed of a weaving vehicle is higher than its freeway leader vehicles (with a negative relative speed) it doesn’t need to accelerate and consequently decelerates in order to avoid collision. The statistical test results presented in Table 1 indicate a significant result was obtained and a relationship is present (in other words, there is a significant relationship between the relative speed and the weaving vehicle acceleration). It is also evident there is a stronger relationship between the weaving vehicle and Lead Veh. 2 compared to Lead Veh. 3. This is due to the fact that under studied traffic conditions a weaving driver has fewer opportunities to accelerate and move to the gap between Lead Veh. 2 and Lead Veh. 3 (G_2 in Figure 1). It is important to mention that this is true in an average sense based on observed sample and for heavy traffic conditions. In free flow condition a driver may be able to freely accelerate and weave in front of Lead Veh 2.

Figure 2-a. Weaving vehicle acceleration rate vs. relative speed for weaving vehicles and freeway leader vehicles (Lead veh. 1) at Southbank weaving section.

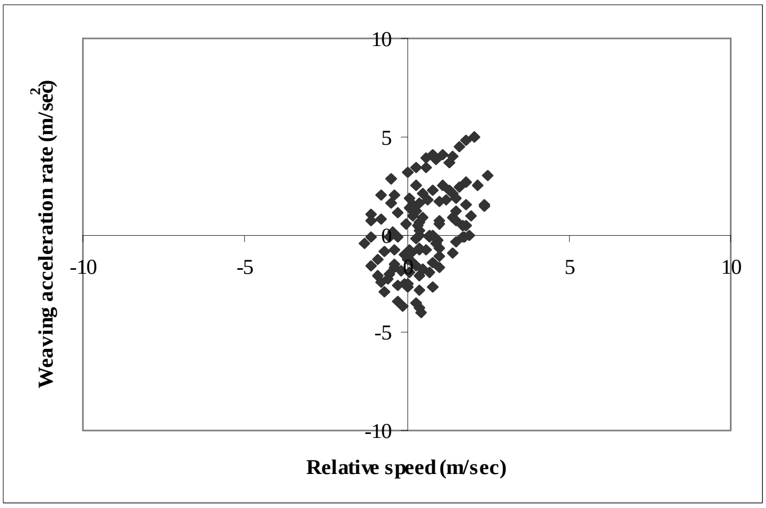


Figure 2-b. Weaving vehicle acceleration rate vs. relative speed for weaving vehicles and freeway leader vehicles (Lead veh. 2) at Southbank weaving section.

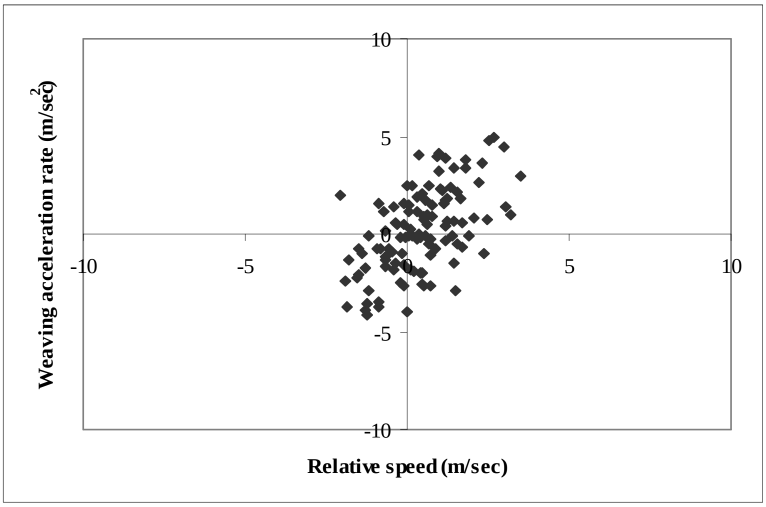
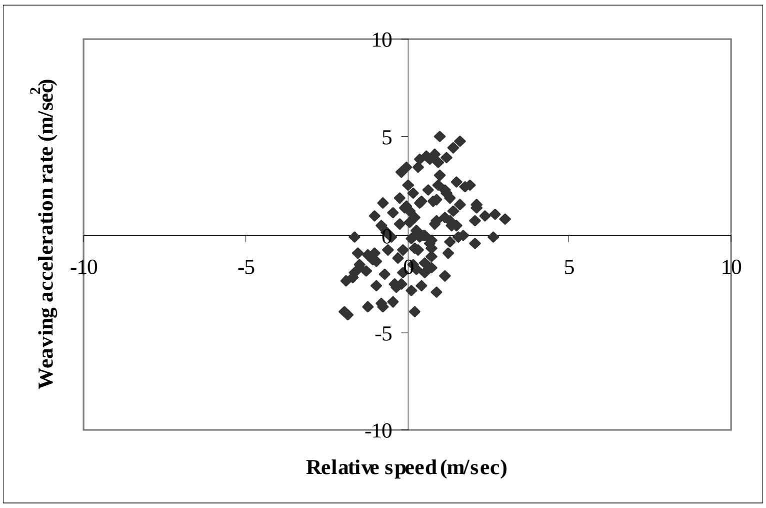


Figure 2-c. Weaving vehicle acceleration rate vs. relative speed for weaving vehicles and freeway leader vehicles (Lead veh. 3) at Southbank weaving section.



3.2. Relative speed between weaving vehicles and its corresponding freeway lag vehicles

Figures 3-a and 3-b show the relationship between the weaving vehicle acceleration and its relative speed for weaving vehicles and freeway lag vehicles (Lag Veh. 1 and Lag Veh. 2 in Figure 1). The relative speed measured with respect to the weaving vehicles is defined as follows:

Relative Speed (Vweaveflag) = weave vehicle speed- freeway lag vehicle speed

Under free flow if a weaving vehicle enters the weaving section with a higher speed than the freeway lag vehicles, a positive relative speed, the weaving driver can then make a lane changing manoeuvre smoothly in front of the adjacent vehicle with minor interaction with the freeway lag vehicles. In contrast, based on Figures 3 under heavy traffic conditions there is a clear interaction between the weaving and the freeway lag vehicles in terms of competing for the limited available space. The statistical test results, shown in Table 1, indicate the presence of a strong statistical relationship.

Figure 3-a. Weaving vehicle acceleration rate vs. relative speed for weaving vehicles and freeway lag vehicles (Lag Veh. 1) at Southbank weaving section.

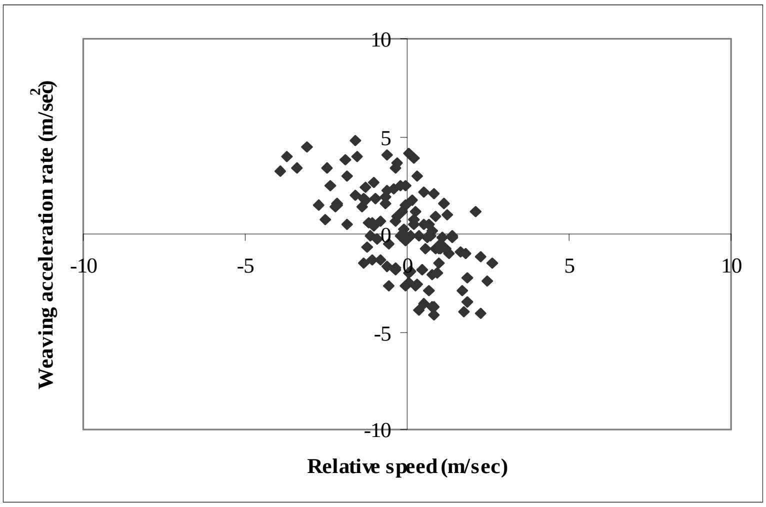
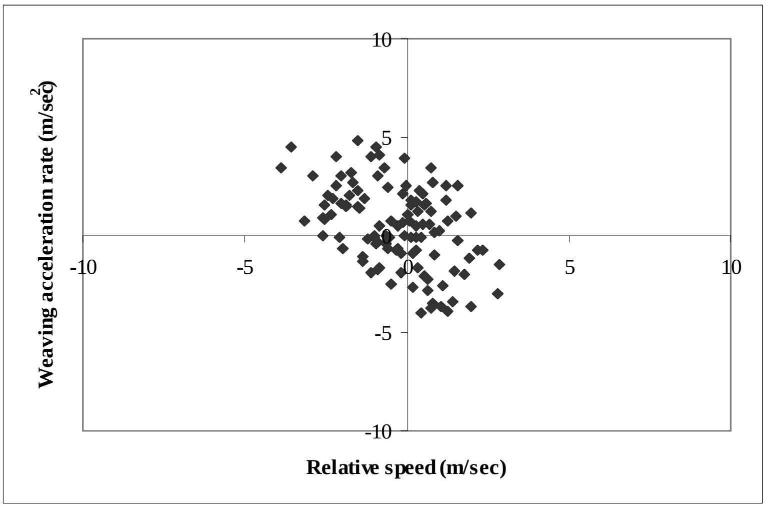


Figure 3-b. Weaving vehicle acceleration rate vs. relative speed for weaving vehicles and freeway lag vehicles (Lag Veh. 2) at Southbank weaving section.



3.3. Spacing between weaving vehicles and its corresponding freeway leader vehicles

Figures 4-a and 4-b show the relationship between the weaving vehicle acceleration and its spacing for freeway leader vehicles and weaving vehicles (Lead Veh. 1 and Lead Veh. 2 in Figure 1). The spacing (the direct distance between the front bumper of the weaving vehicle and the front bumper of the lead vehicle) measured with respect to the weaving vehicles is defined as follows:

Spacing (Sfleadweave) = (Spacing between the freeway lead vehicle and weaving vehicle) - (Desired spacing as a function of speed)

Figure 4-a and 4-b represent a spring action of spacing in which the follower accelerates is drawn ahead when the spacing is larger than the desired value. In other words, if the weaving

driver feels unsatisfied with his spacing, too long or too short, this will inspire him to drive faster or slower to keep or recover the comfortable spacing desired. In this study the desired spacing is referred to as the "spacing", which is a function of the speed and is obtained by fitting a parabolic curve to the observed speed of weaving vehicles and the space between the weaving vehicle and its corresponding freeway leader vehicles (further discussion is also given in section 4 on page 12). The statistical test results shown in Table 1 confirm the existence of a relationship. Additional insight can be obtained from Figure 5 which shows a series of 3D contour plot of relative speed between the weaving vehicles and its freeway leader and lag vehicles.

Figure 4-a. Weaving vehicles acceleration rate vs. spacing between the freeway leader vehicles (Lead Veh. 1) and weaving vehicles at Southbank weaving section.

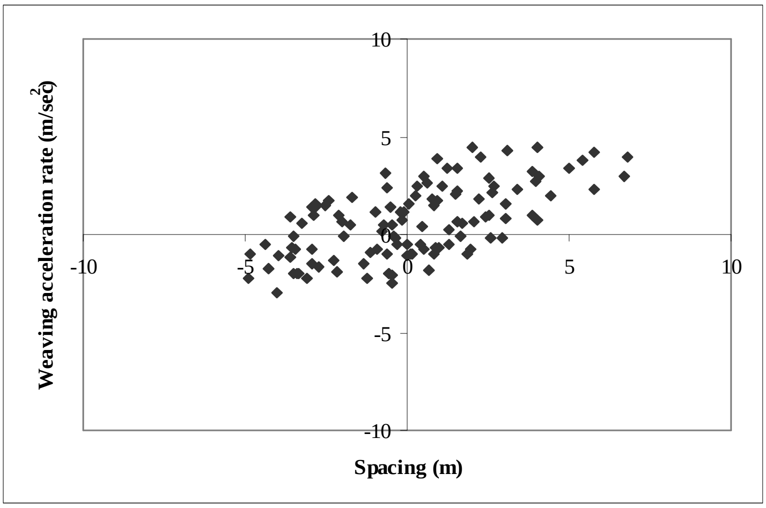


Figure 4-b. Weaving vehicles acceleration rate vs. spacing between the freeway leader vehicles (Lead Veh. 2) and weaving vehicles at Southbank weaving section.

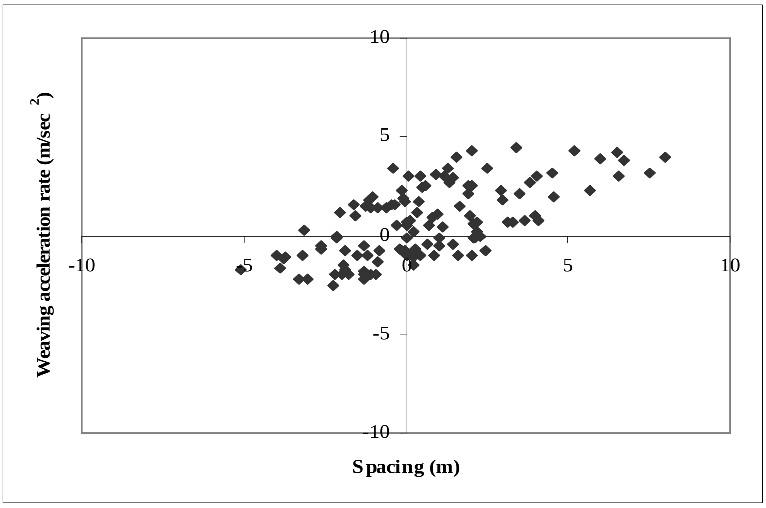


Figure 5. 3D least squares fitted contour plot of relative speed between the weaving vehicles and its freeway leader and lag vehicles.

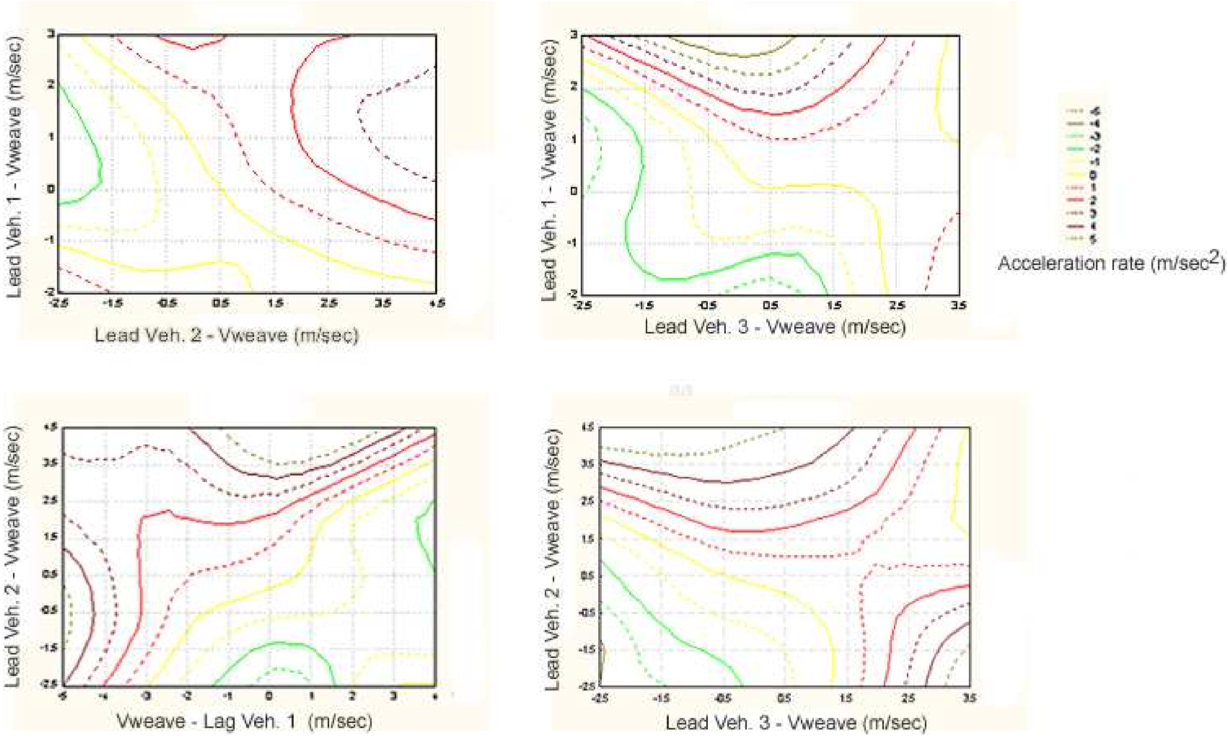


Table 1. Summary results of relationship significance tests

Parameter	Calculated *t* statistic slope	Critical p value (5% significance level)	conclusion
Relative speed between freeway leader (Lead Veh. 1) and weaving vehicle	6.75	7.17E-10	Dependent
Relative speed between freeway leader (Lead Veh. 2) and weaving vehicle	7.12	8.52E-10	Dependent
Relative speed between freeway leader (Lead Veh. 3) and weaving vehicle	5.47	3.79E-07	Dependent
Relative speed between weaving and freeway lag vehicles (Lag Veh. 1)	-5.5	1.95E-07	Dependent
Relative speed between weaving and freeway lag vehicles (Lag Veh. 2)	-2.4	1.1E-03	Dependent
Spacing between freeway leader (Lead Veh. 1) and weaving vehicle	3.9	6E-04	Dependent
Spacing between freeway leader (Lead Veh. 2) and weaving vehicle	3.5	1E-04	Dependent

4. Methodology for modelling weaving driver acceleration behaviour

The movement of a vehicle along a freeway weaving section involves successive navigational decisions, pursuit tracking, positional control relative to other vehicles and roadway elements, and steering into/off the freeway stream. The acceleration-deceleration characteristics for each of these four tasks are different. At the ramp entrance drivers (ramp-to-freeway drivers) normally have to adjust their speed in order to accommodate the controlling conditions of the ramp curvature and super elevation and to make a decision of possible lane changing into the adjacent freeway lane. In contrast freeway-to-ramp drivers try to match their speeds to those of the ramp-to-freeway vehicles, at the merging point of the weaving zone and as they get closer to the off- ramp their behavior are to some extent affected by the geometric condition of the exit ramp.

Under free flow conditions, most diverging vehicles change lanes to the freeway shoulder lane before they reach the weaving section (Fitzpatrick and Nowlin 1996). Besides, under free flow conditions, the weaving vehicles generally first enter the auxiliary lane before they move to the main freeway lanes (Bham 2006). However, in a heavy traffic conditions the weaving driver may stay in queue of vehicles and wait to force a merging/diverging. This procedure may involve deceleration, acceleration reduction, keeping a constant speed, maintaining a current acceleration, or acceleration increase according to the existing conditions. In this study, to model weaving drivers' behavior, a stimuli-response psychophysical concept is employed. The developed theoretical model represents the weaving driver decision process during the weaving manoeuvre. The fundamental psychophysical concept, *Driver Response(t+T) = Sensitivity factors(t) * Stimulus (t)* where t is the time and T is the reaction time, could capture the weaving driver decision process providing the stimuli can be well specified. Based on the results of this study, explained in the preceding sections, under heavy traffic situations the relative speed between the weaving vehicle and its freeway leader and lag vehicles as well as the spacing between the weaving and its freeway lead vehicles can be identified as the main stimuli.

In general, the manoeuvre of a weaving vehicle is mainly influenced by its freeway lag and freeway lead vehicles (moving in the adjacent/target lane), and its associated lead vehicle moving in the current lane (see Figure 1). Significant behavioral differences across different traffic conditions are expected. Seven stimuli are considered for evaluating the weaving driver response: relative speed regarding the freeway leaders, relative speed regarding the freeway lags and the spacing regarding the freeway leaders.
The proposed general expression of freeway weaving vehicle acceleration-deceleration behavior is as follows:

$$a_{Weave}(t+T) = \alpha_0 + \sum_{i=1}^{3}\{\alpha_i \frac{V_{Weave}^{m}(t+T)}{[X_{Flead_i}(t) - X_{Weave}(t)]^{l_i}}[V_{Flead_i}(t) - V_{Weave}(t)]\}$$

$$+\sum_{j=4}^{5}\{\alpha_j \frac{V_{Weave}^{m}(t+T)}{[X_{Weave}(t) - X_{Flag_{J-3}}(t)]^{l_j}}[V_{Weave}(t) - V_{Flag_{J-3}}(t)]\}$$

$$+\sum_{k=6}^{7}\{\alpha_k \frac{S(t)_{k-5} - f[v(t)]}{[X_{Flead_{k-5}}(t) - X_{Weave}(t)]^{l_k}}\} \qquad (1)$$

Where:

$a_{Weave}(t+T)$: Acceleration rate of the freeway weaving vehicle at time t+T (m/s^2)

$X_{Weave}(t)$: Location of the weaving vehicle at time t (m)

$X_{Flead}(t)$: Location of the freeway lead vehicle at time t (m)

$X_{Flag}(t)$: Location of the freeway lag vehicle at time t (m)

$V_{Weave}(t)$: Speed of the weaving vehicle at time t (m/s)

$V_{Flead}(t)$: Speed of the freeway lead vehicle at time t (m/s)

$V_{Flag}(t)$: Speed of the freeway lag vehicle at time t (m/s)

$S(t) = X_{Flead}(t) - X_{Weave}(t)$: Spacing between the freeway leader vehicle (e.g. Lead Veh. 1) and the weaving vehicle at time t (m)

$f[v(t)]$: Desired spacing as a function of speed (m)

$v(t)$: is equal to $V_{Weave}(t)$

T : Time lag or driver reaction time (s)

$\alpha_0, \alpha_i, \alpha_j, \alpha_k, m, l_i, l_j, l_k$ are parameters to be estimated.

The second and third terms in Eq. (1) represent the model of the reaction of a weaving driver to changes in the speed of the corresponding freeway leaders and lags vehicles (Helly 1959 and Parker 1996). The fourth term introduces a spring action related to the spacing between the weaving vehicle and freeway lead vehicles, which causes the follower to accelerate when the spacing is larger than the desired value and decelerate when the spacing is less than the desired value.

Our observations have shown that the weaving behavior of drivers can be classified into five distinct types of driver manoeuvres. These are: (1) Merging from the ramp to the freeway shoulder lane. (2) Entering the freeway shoulder lane from the auxiliary lane. (3) Entering the auxiliary lane from the freeway shoulder lane. (4) A combination of manoeuvres two and three when two vehicles changing lane at the same time. (5) Diverging from the freeway lane into the off-ramp. Our observations have revealed that under heavy traffic conditions there are very few opportunities which facilitate the type four weaving manoeuvres.

The mathematical framework of the proposed general model could be used to capture the behavior of weaving vehicles involved in all types of weaving manoeuvres (type 1 to type 5) described earlier. In other words, different acceleration-deceleration models should be considered for different situations depending on the presence of other corresponding vehicles. For instance, the acceleration-deceleration behavior of a ramp driver (type 1 manoeuvre) approaching the weaving section can be expressed as follows:

$$a_{Weave}(t+T) = \alpha_0 + \alpha_2 \frac{V_{Weave}^{m}(t+T)}{[X_{Flead}(t) - X_{Weave}(t)]^{l_2}} [V_{Flead}(t) - V_{Weave}(t)] \qquad (2)$$

$$+\alpha_4 \frac{V^m_{Weave}(t+T)}{[X_{Weave}(t)-X_{Flag}(t)]^{l_4}}[V_{Weave}(t)-V_{Flag}(t)]$$

$$+\alpha_7 \frac{S(t)-f[v(t)]}{[X_{Flead}(t)-X_{Weave}(t)]^{l_7}}$$

Eq. (2) is a special case of Eq. (1) in that the second and fourth term reflects the effect of the freeway leader vehicle traveling in the freeway shoulder lane, and the third term reflects the impact of the freeway lag vehicle approaching the weaving section from the freeway shoulder lane. In another example, when a weaving vehicle is the leader of a platoon in the auxiliary lane (in the absence of Lead Veh. 1), the weaving vehicle acceleration model is obtained by removing the second and sixth terms from the general formula in Eq. (1).

Eq. (1) has a nonlinear form. A nonlinear regression technique is performed in order to calibrate the parameters in Eq. (1) for different T values.

4.1. Acceleration models

The data collected in this study is not large enough to cover all geometric characteristics and further studies are required. Instead, it can demonstrate the general phenomena to gain greater understanding about the freeway weaving process under heavy traffic conditions. Based on the data collects at the Hakozaki and Southbank weaving sections (based on 130 weaving manoeuvres) the following scenarios are analyzed and used to calibrate the proposed model for weaving manoeuvres of type 2 and 3 described in section 4.

Scenario 1: Hakozaki weaving section
Scenario 2: Southbank weaving section
Scenario 3: Hakozaki and Southbank weaving section

4.2. Calibrating nonlinear acceleration model

To calibrate the acceleration-deceleration model in Eq. (1) for scenarios 1 to 3 a nonlinear regression procedure is used. All possible combinations of the explanatory variable components of Eq. (1) are examined individually (using multivariate analysis and variable screening method using stepwise regression analysis). This procedure ensures that the developed model is robust and of practical use. The statistical analysis software, STATISTICA, was used to solve the regression problems. The analysis was performed for T= 0 second, 0.36 second, 0.72 second, 1.5 second, 2 second, and 2.72 second. The model that has the largest adjusted R^2 value is chosen.

The best fitted acceleration-deceleration model for scenarios 1-3 is shown in Table 2 (the value in bracket is the t statistic).

Table 2. Calibration results for the nonlinear acceleration-deceleration model

Scenario	1 (t statistic)	2 (t statistic)	3 (t statistic)
α_0	-0.39	-0.28	-0.22
α_1	0.201 (2.43)	0.23 (1.57)	0.28 (2.02)
α_2	0.451 (5.55)	0.331 (3.43)	0.297 (3.98)
α_3	0.301 (3.32)	0.211 (2.22)	0.268 (3.01)
α_4	-0.022 (-6.42)	-0.041 (-4.29)	-0.028 (-4.73)
α_5	-0.012 (-5.47)	-0.026 (-5.11)	-0.023 (-2.78)
α_6	0.511 (2.21)	0.469 (3.94)	0.537 (2.71)
α_7	0.712 (2.22)	0.921 (2.73)	0.773 (3.52)
m	2.52	2.22	2.15
l_1	0.441	0.751	0.511
l_2	0.677	0.458	0.331
l_3	0.559	0.811	0.714
l_4	0.771	0.236	0.374
l_5	0.136	0.345	0.221
l_6	1	1	1
l_7	1	1	1
T (reaction time)	0.72	0.72	0.72
Adjusted-R^2	0.61	0.65	0.67

The evidence that the best model is obtained when T, the reaction time, is equal to 0.72 second supports the intuitive knowledge that there exist a time lag between the time a freeway weaving driver detects the stimuli and response time. The positive sign of second, third, and fourth terms in Table 2 explains, assuming all other elements remain constant, that the weaving vehicle decelerates while approaching its freeway lead vehicles. The negative sign of the fifth and sixth terms, conversely, indicate that if the speed of the weaving vehicle is lower than its corresponding freeway lag vehicles, then the weaving vehicle accelerates to force a lane changing. Finally the positive sign of the seventh and eighth terms indicates that the weaving driver always try to keep a desirable spacing based on its speed. These results are consistent with the phenomenon demonstrated in Figures 2 to 5. It is also important to notice that the difference parameters obtained for the two weaving sections could mainly be attributed to the different roadway layout of these two sections. Nevertheless, the general structure of the proposed model is capable of capturing the behavioral aspect of the weaving manoeuvre and the model requires to be calibrated for different sites. It is also important to notice the magnetite of different parameters which highlight the importance of each parameter in the model in order to explain the variability of the dependent variables in regard to the independent variables. For instance the value of α_2 shows its relative importance in explaining the variability of the weaving vehicle acceleration in comparison to α_4.

6. Conclusions

Freeway weaving manoeuvres represent a complex process which involves lane changing, acceleration, deceleration, merging into a gap, and diverging. This paper presents a methodology for collecting field data, analyzing freeway weaving behavior data and developing and calibrating a freeway weaving vehicle acceleration models. Wide ranges of data were collected using videotape and image processing techniques. Comprehensive traffic surveys were conducted at two weaving sections in Tokyo and Melbourne. Based on these observations, a classification of the weaving manoeuvres is proposed. A theoretical framework for modeling the weaving driver acceleration-deceleration behavior is presented. This methodology uses the stimuli-response psychophysical concept as a fundamental rule. Data collected at the two weaving points are used to calibrate the hypothesized weaving vehicle acceleration models.

It is found that the surrounding freeway vehicles significantly affect the weaving vehicle acceleration behavior. The mathematical framework of the developed model could be used to capture the behavior of weaving vehicles involved in all types of lane changing and merging/diverging manoeuvres usually occurring at weaving sections as described in this work.
The proposed model has the advantage of capturing the acceleration-deceleration behavior of drivers during the entire process of weaving manoeuvres. The result presented in this study showed these acceleration behaviors are significantly different from the behaviors of drivers who stay in their lane (i.e. non-weaving vehicles). Nevertheless, the proposed mathematical framework can be applied to obtain the acceleration profile of the surrounding vehicles (e.g. Lead Veh. 2 or Lag Veh. 1 in Figure 1). This can be carried out in the same fashion as explained in the work in order to develop an acceleration/deceleration model for non-weaving vehicles. The assumption of similar acceleration behavior of weaving and non-weaving vehicles (particularly under heavy traffic conditions) could lead to unrealistic results and should be considered by all micro-simulations attempting in modeling freeway weaving sections.

Due to the limited number of study sites used to calibrate the hypothesized model the conclusions drawn from this study are tentative. Generalization of the proposed model to highway sections with different geometrical characteristics should be carried out with cautious, considering the limited weaving sites studied in this work.

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