Drivers' attention distribution characteristics in cutting-in process on freeway

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Abstract

In order to explore the influence of interfering car on attention distribution characteristics and guide new drivers to allocate their attention reasonably, real vehicle experiments in a freeway environment were carried out using eye movement instrument faceLAB 5.Eye movement data of 13 drivers were collected and recorded.And then,drivers' attention distribution characteristics were analyzed when interfering car cutting in from different sides. Besides, drivers' fixation transfer rules between different fixation areas were studied. The results show that in the process of interfering car cutting in,the driver mainly focuses on the front view,especially pays more attention to dynamic targets such as front vehicle and interfering car, and that the driver pays more attention to the side where interfering car cutting in.

Keywords

Traffic engineering, interfering car-following, Markov theory, attention, distribution characteristics.

1. Introduction

According to car-following theory, when the distance between the front and rear workshops is less than 125 m, the driver of the rear car will respond regularly to a series of continuous stimuli of the front car by means of perception, judgment and control ability. This process is called car-following process [1].

Domestic and foreign scholars have shown that eye movement is the most effective way to reflect driver's attention allocation [2-3]. However, previous studies have not considered the driver's attention characteristics when disturbing car-following. In view of this, the author will carry out a real vehicle test aiming at the impact of interference vehicle entry on driver's attention, collect and analyze driver's eye movement behavior data, so as to provide theoretical basis for novice driver's visual search ability training.

2. Disturbing driver's gaze during car following

2.1 Division of gaze region

Considering the different entry directions of the interfering vehicle, the driver's gaze area is divided into six regions, as shown in Table 1. In faceLAB 5, the coordinate origin is in the center of the driver's eye line, X axis is horizontal axis, right is positive, Y axis is vertical axis, upward is positive. Rotating the line of sight around the X and Y axes indicates that the driver is gazing at the upper and lower positions and the left and right positions in the traffic scene, respectively.

Table 1 Fixation objects classification

code	name
CL	Current Lane
LA	Left Area
RA	Right Area
OC	Objective Car
IC	Interfere Car

OA	Other Area

2.2 Distribution of Attention during Left-Side Cut-in of Disturbance Vehicle

2.2.1 Distribution of gaze

Drivers mainly rely on eye gaze behavior to obtain traffic information. By studying the driver's gaze probability in each region, the gaze distribution during high-speed disturbance is analyzed.

2.2.2 Rotation of line of sight

In the vertical direction, the rotation angle of the line of sight concentrates in the range of [-20, 10], which indicates that the driver observes the area between OC and the vehicle, and mainly focuses on the slightly lower position of the forward visual field. Vertical rotation angle in the range of[-30, -20], indicates that the driver needs to observe the dashboard in order to better control the speed.

2.3 Distribution of Attention in Interrupting Right-Side Cut-in

2.3.1 Distribution of gaze

The driver's attention distribution and sight rotation are shown in Fig 1 and 2.

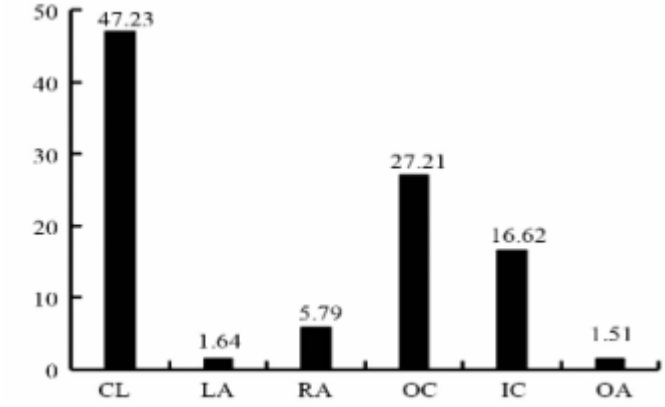

Fig.1 Visual line rotation when vehicle cutting-infrom right side

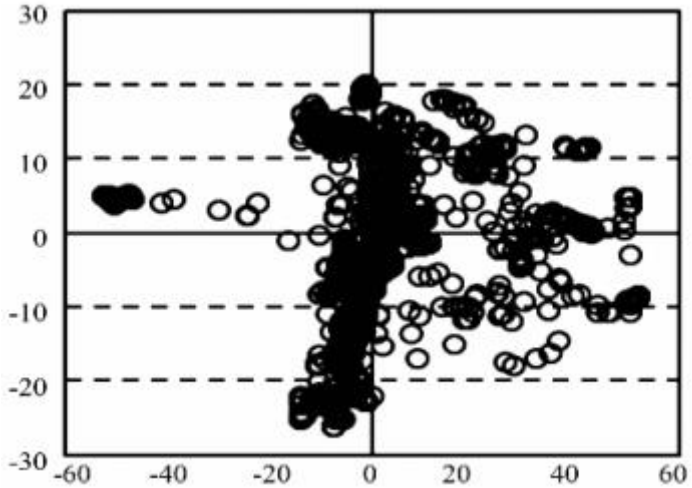

Fig.2 Visual line rotation when vehiclecutting-in from right side

From Fig1, it can be seen that when the disturbing vehicle cuts in from the right side, the driver has the highest probability of looking at CL and OC, and the driver needs to focus most of his attention on the front field of vision, which is similar to the left side of the car. In addition, the driver's gaze probability on the direction of interference side entry is also higher, and the gaze probability of RA is much higher than that of LA.

When the jammer vehicle cuts in from different directions, the driver's gaze proportion varies greatly. The probability of the left-side entry gaze (26.59%) is significantly higher than that of the right-side entry gaze (16.62%). This is because driving on the left side in our country makes it easier for the driver to observe the target of the left-side lane, and the rotation angle of head and visual line is much

smaller than that of the right-side target. This is why the collision probability in the right front of the vehicle is higher than that in the left front.

2.3.2 Line of sight rotation

As shown in Fig.2, the rotation angle of the vertical line of sight is distributed in[-25, 20], which means that the driver mainly observes the area between the vehicle in front and the vehicle in front of him and concentrates on the downward position. When the vertical angle is less than -20 degrees, it means that the driver is observing the inside of the speedometer and other vehicles.

When the jammer vehicle cuts into the right side, the horizontal line of sight distributes in the[-60, 60], and concentrates in the middle right area, indicating that the driver's area of concern is the front and right area. Drivers pay more attention to RA and have a wide range of coverage, which indicates that drivers always pay attention to interfering vehicles. The dynamic process of entering the current Lane on the right.

3. Gaze transfer pattern

3.1 Disturbance of Watch Transfer Mode in Left-Side Cut-in of Vehicle

The dynamic shift of driver's vision can reflect the distribution of attention. Because of the ineffectiveness of the Markov chain, the driver's line-of-sight shift can be regarded as a typical homogeneous Markov chain[4]. Using this theory, the transfer rule of driver's dynamic vision in the gaze area is studied, and the transfer path of driver's vision between different areas is analyzed statistically. The probability matrix of gaze transfer (expressed in P) is obtained. See Table 2. Whereas, I-j represents the probability of the line of sight shifting from region I to region j, i, j={CL, LA, RA, OC, IC, OA}.

Table 2 Fixation's transition probabilities when vehicle cutting-in from left side

Area	CL	LA	RA	OC	IC	OA
CL	0.000	0.176	0.224	0.283	0.317*	0.000
LA	0.193	0.000	0.000	0.362*	0.319	0.126
RA	0.170	0.000	0.000	0.540*	0.290	0.023
OC	0.237	0.106	0.075	0.000	0.547*	0.035
IC	0.519*	0.112	0.077	0.216	0.000	0.076
OA	0.346*	0.238	0.043	0.231	0.142	0.000

Note: * indicates that the transfer probability of gaze from other regions to this region is the greatest; Table 3 is the same.

From Table 2, it can be seen that the driver mainly focuses on the front view (CL and OC) when following the car normally. When the disturbing car cuts in from the left, the driver allocates part of his attention to the disturbing car (IC) and the left area (LA). Therefore, the transfer probability of gaze between the four regions is higher.

3.2 Disturbance of Watch Transfer Mode in Right-Side Intersection of Vehicle

The driver's attention allocation characteristics when jamming vehicle cuts in from the right side are both related and different from that when it cuts in from the left side, as shown in Table 3.

Table 3 Fixation's transition probabilities when vehicle cutting-in from right side

Area	CL	LA	RA	OC	IC	OA
CL	0.000	0.135	0.223	0.393*	0.231	0.018
LA	0.307	0.000	0.000	0.374*	0.217	0.102
RA	0.233	0.144	0.000	0.367*	0.139	0.117
OC	0.257	0.131	0.358*	0.000	0.145	0.109
IC	0.212	0.000	0.249	0.407*	0.000	0.132
OA	0.328*	0.134	0.205	0.173	0.160	0.000

When the current focus area is CL, the driver takes OC as the main objective of affecting driving safety, and needs to observe OC repeatedly to maintain a certain distance with the car. $P_{RA\text{-}OC}$ is 0.367

when the area of attention is RA, which indicates that the driver should observe the right guardrail, traffic signs and the right vehicle before observing the current Lane in order to maintain the safe position of the vehicle in the lane.

When the current gaze area is OC, the P_{OC-RA} is 0.358, which indicates that when the disturbing vehicle cuts in from the right, the driver observes the dynamic traffic flow in the right area. In addition, the value of P_{IC-OC} is 0.407, which indicates that the driver needs to observe the vehicle in front and the disturbing vehicle simultaneously to maintain a safe following distance.

4. Conclusion

Drivers' attention will be affected by the disturbed vehicle when following the vehicle in the highway environment, but the main focus is still on the lower position in front of the vision field.

The driver's attention points are distributed more and more dispersedly on the entry side of the interfering vehicle, which indicates that more attention needs to be allocated in order to observe the movement of the interfering vehicle many times. The driver's sight shifts more in the dynamic target areas such as the vehicle ahead and the jamming vehicle, and is higher than the static target.

When disturbing vehicle entry, the influence of the front car in normal car-following process will be reduced, and the influence of disturbing vehicle will be increased gradually. This result can be used as a basis to guide novice drivers to allocate their attention reasonably.

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