Research on the Influence Law of Driving Experience on Drivers’ Gaze Behavior

Bingkui Ji*, Xueping Yao and Mingda Li

School of Mechanical and Electrical Engineering, Changchun Institute of technology, Changchun130012, China

*Corresponding author e-mail: bingkui2008@163.com

Abstract. To collect the information about driver’s visual features and the manipulation to vehicles, an experiment platform is built based on eye movement tracking device-Smart Eye, GPS, accident recorder equipment etc. We select a typical urban road to test. By analyzing the changes on different experience driver’s visual features at peak and peaceful peak period, find out the change laws of different experience drivers in their driving process. Some theoretical bases are provided for studying driver features.

1. Introduction
When driving on urban road, about 80%-90% information of drivers for safe driving is from eyes, and 95% information is dynamic [1]. Numerous studies show that safe driving is most closely related to the drivers’ dynamic visual features. The drivers’ dynamic visual features mainly mean fixation features, including fixation time, fixation area and fixation direction etc. So drivers’ dynamic visual feature is an important part of studying the drivers’ behavioral characteristics.

Automobile transportation security technology Key Laboratory of the transportation industry of Chang’an University analyzed the speed variation, drivers’ eye movement characteristics and operation behavior on different width road using T. K. K. 940 [2], also studied driver’s fixation theory and visual search behavior [3]. Yuan Wei[4] implement large sample test in real urban traffic environment using Eye Link II. The methods of determining driver's interesting fixation area by dynamic clustering theory and classify and identify driving proficiency by fuzzy theory are proposed [5]. Lu Jian [6] conducted some experiments on real roads to study the influence of gaze fixation distribution, mean fixation duration and visual angle distribution on traffic flows, and modify the saturation-flow-rate model that is used to calculate intersection capacity.

Different traffic conditions will bring different influence for different experience drivers and it also cause driver’s fixation objective, interesting fixation area differently. So, it is necessary for studying driver’s visual features of different experience drivers in various traffic environments.

2. The Construction of experiment system
An experiment system is constructed based on eye movement tracking device-Smart Eye, Biopac, GPS, accident recorder equipment, car camera. Smart Eye can collect driver’s visual features, such as fixation orbit, fixation range, fixation time, interesting fixation point etc. Biopac can collect driver’s physiological features, such as ECG, EEG, EMG, respiration. GPS can collect vehicle speed and
location. Car camera can record driver’s manipulation to vehicle. The experiment system is showed in Fig.1.

3. The selection of experimental program

3.1. Experiment route

In order to cover all types of urban roads, we select the following route in Changchun: West gate of Jilin University-Renmin Street-Changbai Road-Yaitai Street-Nanhu Road-Yanan Street-Ziyou Road-Renmin Street-West gate of Jilin University. This route includes intersections, roundabouts, urban ordinary roads and urban expressways, and passes railway station. Volume of traffic is large, pedestrians and vehicles cause more horizontal interference. These are typical characteristics of urban roads.

3.2. Driver

According to the driving experience, three drivers are selected, marked with driver1, driver2, driver3, as the represented drivers of skilled, generally skilled and unskilled. The main information of drivers is shown in table 1.

| Driver Number | Age | Driving Age(year) |
|---------------|-----|-------------------|
| Driver1       | 45  | 20                |
| Driver2       | 40  | 10                |
| Driver3       | 23  | 1                 |

3.3. Experiment method

Selecting testing time in peak and peaceful peak period, drivers drive the test car as their driving habits on experiment route (The drivers have been told before experiment). The eye movement data are collected by Smart Eye. These data not only include the driver's eye movement data at normal driving, but also include driver's eye movement data at traffic congestion and red light.

4. The analysis of fixation time

4.1. Calculation of fixation time

Import the data into data analysis software SPSS, and select the fixation data. According to fixed sample frequency of Smart Eye, we can calculate the total fixation time by Equation (1).

$$T_{\text{fixation}} = N / f$$  (1)
Where $T_{\text{fixation}}$ is the total fixation time, $N$ is the number of fixation data, $f$ is the sample frequency of Smart Eye.

The sample frequency of Smart Eye is 60HZ, according to Equation.1, we calculate three drivers total fixation time and mean fixation time. The results are shown in Table 2.

| Drivers’ fixation data | Number of fixation | Total fixation time (s) | Mean fixation time (s) |
|------------------------|--------------------|-------------------------|------------------------|
|                        | Peak               | Peaceful peak           | Peak                   | Peaceful peak |
| Driver 1               | 36568              | 29077                   | 1296.93                | 1189.40       | 35.47         | 40.91         |
| Driver 2               | 20743              | 21005                   | 1228.35                | 1543.42       | 59.22         | 73.48         |
| Driver 3               | 19232              | 26564                   | 2190                   | 4240          | 113.87        | 159.61        |

The analysis of duration fixation

Fixation behavior occurs frequently in an experiment, it is impossible to calculate every fixation time. So we cut up the duration fixation time as the following subparagraphs:

$[0,100 ms), [100, 200 ms), [200, 300 ms), [300, 400 ms), [400, 500 ms), [500, 600 ms), [600, 700 ms), [700, 800 ms), [800, 900 ms), [900, +\infty)$

The percent of every subparagraph at peak and peaceful peak period are shown in Figure 2 and Figure 3.

From Fig.2 and Fig.3, we can conclude that the drivers’ duration fixation time mainly locates at the three subparagraphs of $[0,100 ms), [100, 200 ms), [200, 300 ms)$ at peaceful peak period and at the two subparagraphs of $[0,100 ms), [100, 200 ms)$ at peak period. It is because that the traffic condition is complicated at peak period. Drivers need fast eye movement speed to collect more traffic information.

So the drivers’ duration fixation time is shorter at peak period than that at peaceful peak period. With the driving experience increasing, the changes of drivers’ duration fixation time become stable. So the influence of traffic flows changes on drivers will decrease with the increasing of driving experience.

Figure 2. The percent of every subparagraph at peak

Figure 3. The percent of every subparagraph at peaceful peak
5. The analysis of fixation area

5.1. Dipartition of fixation areas
Drivers can choose the traffic information which is helpful to safe driving, different drivers gaze different areas when they drive. To research their interesting fixation area and the law of fixation area changes, we divide drivers’ fixation area into the following seven parts: left mirror, left lane, far side of front lane, near side of front lane, right lane, right mirror, dashboard. The dipartition of fixation area is shown in Fig. 4. The main visual objects in each fixation area are shown in Table 3.

Drivers’ fixation time in the seven parts and its percent of total time are shown in Table 4. From Table 4, the skilled drivers’ fixation time is longer than unskilled drivers at same time and route.

Table 3. Main visual objects in each fixation area

| Fixation area | A          | B          | C          | D          | E          | F          | G          |
|---------------|------------|------------|------------|------------|------------|------------|------------|
| Visual objects| left mirror| left lane  | far side of front lane | near side of front lane | right lane | right mirror | dashboard |

Table 4. Drivers’ fixation time in the seven parts and its percent of total time

| Driver1 peaceful peak | Driver2 peaceful peak | Driver3 peaceful peak | Driver1 peak | Driver2 peak | Driver3 peak |
|-----------------------|-----------------------|-----------------------|--------------|--------------|--------------|
| Time (s) | Percent | Time (s) | Percent | Time (s) | Percent | Time (s) | Percent | Time (s) | Percent | Time (s) | Percent |
| A | 84.42 | 1.74 | 31.84 | 1.30 | 47.13 | 1.86 | 69.21 | 1.31 | 34.80 | 1.31 | 34.57 | 0.56 |
| B | 26.16 | 0.54 | 3.65 | 0.15 | 245.05 | 9.64 | 78.07 | 1.62 | 5.41 | 0.20 | 106.97 | 1.73 |
| C | 24.41 | 0.50 | 0.33 | 0.01 | 2.70 | 0.11 | 10.86 | 0.23 | 0.35 | 0.01 | 3.82 | 0.06 |
| D | 2599.27 | 53.60 | 1015.54 | 41.44 | 1027.92 | 40.63 | 1956.25 | 40.63 | 914.89 | 34.50 | 2761.79 | 44.54 |
| E | 342.77 | 7.07 | 5.24 | 0.21 | 29.17 | 1.15 | 207.73 | 4.31 | 26.34 | 0.99 | 71.65 | 1.16 |
| F | 16.13 | 0.33 | 2.52 | 0.10 | 1.77 | 0.07 | 8.24 | 0.17 | 5.42 | 0.20 | 1.70 | 0.03 |
| G | 34.15 | 0.70 | 35.14 | 1.43 | 11.56 | 0.46 | 56.46 | 1.17 | 80.95 | 3.05 | 59.66 | 0.96 |
| Driving time | 4849.65 | 2450.42 | 2540.78 | 4814.92 | 2651.85 | 6200.80 |

Figure 4. The dipartition of fixation area

5.2. The analysis of fixation time in seven parts
Fig. 5 and Fig. 6 show the percent of drivers’ fixation time in seven parts at peak and peaceful peak period. We can conclude that drivers’ most interesting fixation area is heading lane at both peak and peaceful peak period. Heading lane is the mainly area of getting traffic information for drivers. Skilled and generally skilled drivers’ second interesting fixation area is right lane, but unskilled drivers’ is left lane. Furthermore, skilled and generally skilled drivers can gaze the other four parts expect heading lane, unskilled drivers nearly don’t gaze the other parts. So with the increase of driving experience, drivers’ fixation area will get wider. It is beneficial for safe driving.
Figure 5. Percent of drivers’ fixation time in seven parts at peak period

Figure 6. Percent of drivers’ fixation time in seven parts at peaceful peak period

6. Conclusion

From above on, the following conclusions are obtained:

• The drivers’ fixation numbers and mean fixation time will decrease with the increasing of driving experience. The drivers’ mean fixation time at peaceful peak period is longer than that at peak period.

• Drivers’ duration fixation time mainly locates at the three subparagraphs of at peaceful peak period and in the two subparagraphs of at peak period. The drivers’ duration fixation time is shorter at peak period than that at peaceful peak period. With the driving experience increasing, the changes of drivers’ duration fixation time become stable.

• Drivers’ most interesting fixation area is heading lane at both peak and peaceful peak. Heading lane is the mainly area of getting traffic information for drivers.

• Skilled and generally skilled drivers will gaze right lane more often than the other areas except heading lane, however unskilled drivers will gaze left lane more. So with the increasing of driving experience, drivers’ fixation area will get wider. It is beneficial for safe driving.

• In different traffic environment, fixation numbers, mean fixation time and fixation areas of different experience drivers are different. Skilled drivers are relaxed when they drive vehicles. They can collect the information which is necessary for driving in short time. So the mean fixation time of skilled drivers is short, and fixation numbers and fixation area are big. Unskilled drivers are nervous when they drive, and information processing is slow, so their eye movement speed is low and fixation area is narrow.

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