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Research Article

Determination of English Letter Height of Road Signs for Foreign Drivers Based on Animation Technology

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Abstract: The aim of this study is to develop a new English letter height model for guide signs to solve the problem that foreign drivers are often not able to read the letter in time and decrease the accident rate. The model was built according to the visual and kinematic theory based on the legibility process of drivers and animation technology. Then the key parameters of the model were validated by some special designed simulation experiments. The experiment was designed to determine the minimum visual angle needed. The relationship between the information units and the reaction time was studied based on animation technology. The disappearing distance was computed according to the geometric relationship considering road width, the height of the sign and the disappearing angle. In the end, the letter height for various design speed was computed. The model of the height of the English letter in the Chinese guide sign was built at the first time and it is projected to play a big role in the traffic safety.

Keywords: Animation technology, English letter height, road signs

INTRODUCTION

The letter height model in guide signs is one of the fundamental problems in traffic engineering. Foreign drivers can only recognize the letter close to the exit of the road or miss the exit because of inadequate height of the letters and thereby many accidents were caused. Figure 1 is an example of small English letters. However, it is a waste of money with too large letters (China, 1999). So it is necessary to conduct research on the study of the English letter height in traffic signs.

Much research was conducted on in the United States (Zeltner *et al*., 1988; Forbes *et al*., 1950). Al-Madani (2002) built the letter height model of the alphabet. Japan carried out research on the letter height of Japanese letters (Road Association of Japan, 1962), but the results could not be utilized because of the difference in traffic environment. The English letter height in the Chinese guide signs was given based on experience and the soundness needs examining.

In view of the problems above, the English letter height model was built based on the kinematics theory and drivers' reading character and key parameters were examined by means of simulation and experiments.

INFORMATION PROCESSING OF DRIVERS

Figure 2 shows the information intake process of drivers (Wang, 1988, 2008; Lin, 2005).

F was the position placing signs. Drivers viewed the sign in point A and could recognize the information

Fig. 1: Inadequate height of English letters in guide signs

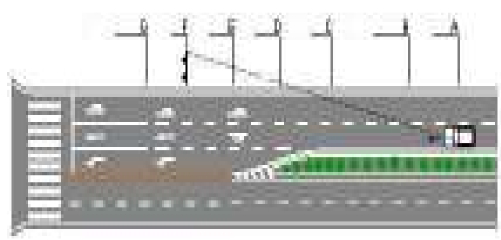

Fig. 2: Information processing of drivers

in point B and started to read the information, then finished reading in point C, after information was processed, actions were taken in point E and were finished in point G. In the disappearing point D drivers can not recognize the information because of the limitation of the visual angle.

In order to meet the drivers' demand of dealing with information, adequate time must be given so that drivers had time to read the information, in other words,

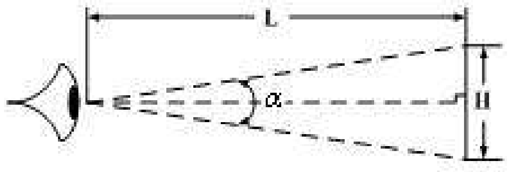

Fig. 3: Eyesight and visual angle

the legibility ending point C must precede the disappearing point D. To ensure the adequate time, the letter height must be designed appropriately. The reasonable letter height model is the problem to be solved.

ENGLISH LETTER HEIGHT MODEL BASED ON INFORMATION PROCESSING AND KINEMATIC THEORY

The letter height in the model was the minimum height required, the two hypotheses are as follows:

- Drivers recognize the letter in point B
- The C point where drivers finish reading the information overlaps with the disappearing point D.

According to the visual theory, eyesight is the ability people discern the detail, generally expressed by visual angle. The reciprocal of the eyesight is the minimum angle which eyes can discern, for example, one whose eyesight is 1.0 can discern a minimum angle of 1′.

As can be seen from Fig. 3, the letter height could be given by the following formula based on the visual theory:

$$H = L\times\alpha \qquad (1)$$

Based on the kinematics theory, the distance between the recognition point B and the locating point F can be computed as:

$$L = V\times t+L_{dis} \qquad (2)$$

In the formula,

V = The vehicle speed, t is the reading time

L_{dis} = The disappearing distance

In formula 1,

α = The visual angle needed to discern the letter and it is determined by the level of eyesight.

Combine the formula 1 and 2, the following formula is built:

$$L = (V\times t+L_{dis})\times\alpha \qquad (3)$$

KEY PARAMETERS VALIDATING BASED ON THE CHARACTERS OF DRIVERS AND TRAFFIC ENVIRONMENT IN CHINA

The values of visual angle α, reading time t and disappearing distance Ld is should be determined based on the traffic environment in China.

- **Visual angle:** The visual angle α will be determined by in-door experiments. 30 subjects (foreigners) with eyesight of 1.0 were chosen, of which 5 were women. The number of the age 20-25, 26-50, greater than 50 groups was 8, 16 and 6 respectively. 26 English letters with different strokes and frequency were used.

The images of the letter were projected to the subjects. Each picture was displayed for 5 sec. Subjects sat at a 6.7 m distance away from the screen, the letter heights of 20, 19, 18, 17, 16 mm, respectively were shown and the corresponding visual angles were 10.3′, 9.8′, 9.3′, 8.8′, 8.3′. When the subjects recognized the letter they told the experimenter what they read otherwise said no, the experimenter recorded the correctness of the judgment. The statistical results were as follows:

As shown in the Fig. 4, when the visual angle decreased to 8.8′, the right judgment percentage decreased significantly, only with 87.6%. To ensure the percentage of 90%, the minimal visual angle chosen was 9.3′.

- **The legibility time based on animation technology:** To obtain the value of the reading time, in-door simulation experiments were designed.

First define the time needed to find the direction of destination in the sign as the legibility time. Through investigation the information which contains two or three words made up the most percentage, so the information unit studied in this essay contained three words. The number of information unit was from 2 to 10.

The animation technology of 3D was used to get videos to simulate the actual traffic environment. At first, the CAD model of road and roadside facilities were built and then loaded into 3DSMAX to generate the road model. After that, the structure of the sign, such as the post, beams and the panel of the sign was added. At last, the car model was chosen and speed was loaded. The 3DSMAX model was run and the video was rendered. The frequency was set up to 40/s. Figure 5 was the virtual scene of drivers recognizing signs.

The software E-Prime was used to show videos to the subjects. Subjects were told a destination road name

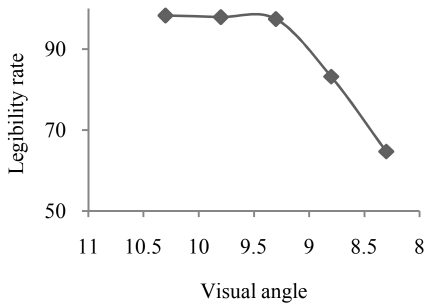

Fig. 4: The relationship between the correctness and the visual angle

Fig. 5: The scene of drivers recognizing signs

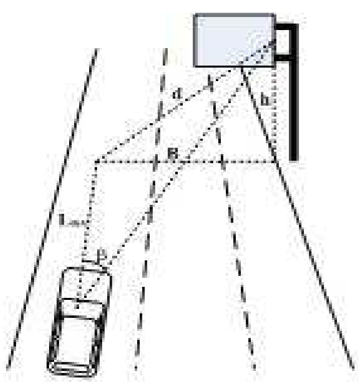

Fig. 6: The disappearing distance

at first and then signs were projected to the subjects in the form of videos. At first, subjects could only detect the shape and color of the signs, when subjects could recognize the letters in the sign, they were asked to press a button, after reading the sign, subjects pressed another button to finish reading the sign. The experimenter then asked subjects the direction of the destination place, if the answer was right, it would be recorded otherwise unaccepted. Subjects continued with other video until the end. The results of the legibility time were automatically recorded in the text form.

The measured time contained a reaction time of the hand pressing button which should be deducted. The modified results of the legibility time were shown in Table 1.

Table 1: The legibility time of signs

Information unit	2	3	4	5	6
Legibility time/S	1.134	1.473	1.534	1.966	2.479
Information unit	7	8	9	10	
Legibility time/S	2.989	3.567	3.865	4.453	

Table 2: Disappearing distance L_{dis}

Speed (km/h)	40	60	80	100	120
Disappearing distance (m)	44.1	44.1	44.1	44.1	60.7

It could be found from Table 1 that there was a close relationship between the number of information units and the legibility time. The legibility time increased from 1.134s to 2.479s as the number of information units increased from 2 to 6. The growth of the legibility time was stable when the number of information units was less than 6 but when it exceeded 6, the legibility time increased sharply. So we advised the ultimate information of a sign be 6 information units and the corresponding legibility time was 2.479s. To get a round number, 2.5s was chosen.

- **The disappearing distance** L_{dis}**:** When vehicles travel at a certain distance away from the sign, the sign will be out of the visual field and this point is called the disappearing point, the distance between the disappearing point and the sign is the disappearing distance.

The following relationship could be established according to the geometric relationship shown in Fig. 6:

$$L_{dis} = d / tg\beta = \sqrt{H^2 + B^2} / tg\beta \quad (4)$$

d is the plane distance between the standing point and the sign, β was half angle of the visual cone, h was the vertical distance between the reading point and the sign, B was the lateral distance between the driver and the sign.

By referring to relevant study (Zhang, 2000), when the speed was less than 100 km/h, β was 15°, when the speed was greater than 120 km/h, β was 11°. Taking the usual two-lane roads in one direction for example, by referring to Technical Standard of Highway Engineering (China, 2004), B is 10m and H is 6.3 m. The disappearing distance shown in Table 2 under different speed could be computed.

COMPUTATION BASED ON THE MODEL

Substitute the legibility time 2.5s into formula 3, the following formula could be established:

$$L = (V \times 2.5 + L_{dis}) \times \alpha \quad (5)$$

Transform the visual angle 15.5’ to radian form and the formula 5 was as follows:

Table 3: The letter height in guide signs under different speeds

Speed (km/h)	120		80	70	60	40
Computed by model (cm)	39.0	36.5	27.0	25.0	23.0	19.5

$$H = 0.002736\times(2.5V + Ldis) \quad (6)$$

Substitute the disappearing distance in Table 2 into formula 6, the results of letter height H under different speeds were computed. The value computed by the model was shown in Table 3.

CONCLUSION AND OUTLOOK

This essay formulates the model of English letter height. It will provide theoretic foundation for the letter height determination in the guide signs and play a big role in the traffic safety.

The following findings could be reached based on the essay:

- The ultimate information in guide signs is 6 units and the corresponding legibility time was 2.5s
- The model was calibrated in simulation experiments and it should be validated in dynamic vehicle experiment in the next step.

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