

Research on Chinese character height model of guide signs based on 3D technology and information processing characteristics of Chinese drivers

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Abstract—drivers are often not able to recognize the letter in time and sometimes it is a waste of money with too large letters in guide signs. In order to solve this problem, a new Chinese character height model for guide signs has been developed based on 3D technology and the apperceive characteristics of Chinese drivers. The model was built according to the visual and kinematic theory based on the legibility process of drivers. 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 3D technology. The disappearing distance was computed according to the geometric relationship concerning about road width, the height of the sign and the disappearing angle. In the end, the letter height for various design speed was computed and compared with the value specified in the standard. The results revealed that the height value of Chinese characters in guide signs which was computed in the model has a relatively good consistence with the current value in national standard, but the value in the standard is a bit small for high speeds and high for low speed. The model of Chinese letter height was built at the first time and it is projected to play a big role in the traffic safety.

Keywords- Information processing, guide signs, Character height, 3D technology

I INTRODUCTION

The height model of characters in guide signs is one of the fundamental models in traffic engineering. 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. Fig 1 is an example of small letter. However, it is a waste of money with too large letters. So it is necessary to conduct research on the study of the letter height in traffic signs.



Fig 1 inadequate height of letters in guide signs

Considerable research was carried out in the United States (1, 2). Hashim Al-Madani built the letter height model of the alphabet (3). Japan conducted research on the letter height of Japanese letters (4), but the results could not be utilized because of the difference in traffic environment, drivers' characters and the configuration of letters. The Chinese letter height in the standard was given based on experience (5), and the soundness needs examining.

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

II INFORMATION PROCESSING OF DRIVERS

Figure 2 was the information processing of drivers (6).

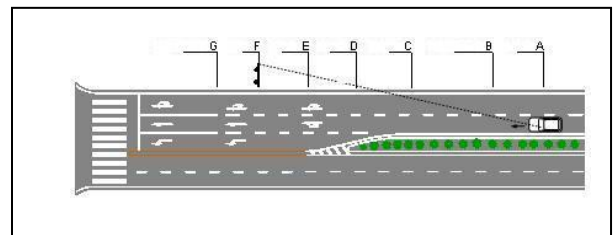


Fig 2 information processing of drivers

F was the point placing signs. Drivers detected the sign in point A, and could recognize the information in point B and started to read the information, then finished reading in point C, after information was processed, actions were initiated 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' need of dealing with information, adequate time must be ensured so that drivers had time to read the information, in other words, 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 this essay will solve.

III CHARACTER HEIGHT MODEL BASED ON INFORMATION PROCESSING AND KINEMATIC THEORY

The character height in the model was the minimum height required, the two hypothesis are as follows:

(1) drivers recognize the character in point B;

(2) 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 in 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 $1'$.

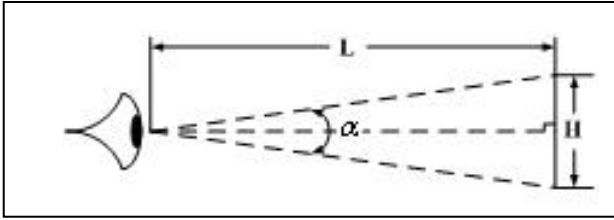


Fig 3 eyesight and visual angle

The character height could be computed in the following formula based on the visual theory:

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

Based on the kinematics theory, the distance between the recognition point of B and the placing point of F can be expressed as:

$$L = V \times t + L_{\text{消失}} \quad (2)$$

In the formula, V is the traveling speed, t is the legibility time, $L_{\text{消失}}$ is the disappearing distance of signs.

In formula 1, α is the visual angle needed to recognize the character, and it is determined by the level of eyesight.

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

$$H = (V \times t + L_{\text{消失}}) \times \alpha \quad (3)$$

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

The values of visual angle α , legibility time t, disappearing distance $L_{\text{消失}}$ should be validated based on the characters of drivers and traffic environment in China.

(1) visual angle

The visual angle α will be measured by in-door experiments. 30 subjects with eyesight of 1.0 were selected, of which 5 were women. The number of the age 20-25, 26-50, greater than 50 group was 8, 16 and 6 respectively. 153 Chinese characters with different strokes, structure and frequency were used.

The pictures of the character were projected to the subjects. Each picture was displayed 5 seconds. Subjects sat at a 4m distance away from the screen, the character heights of 20mm, 19mm, 18mm, 17mm, 16mm were shown and the corresponding visual angles were $17.2'$, $16.3'$, $15.5'$, $14.6'$, $13.8'$. When the subjects recognized the character they told the experimenter what they read otherwise answered no, the experimenter recorded the correctness of the judge. The statistical results were as follows:

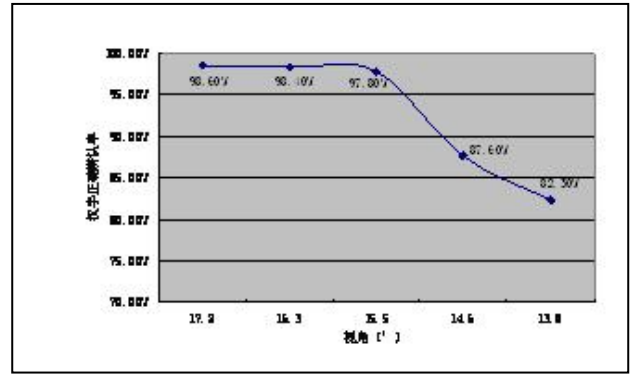


Fig 4 the relationship between the correctness and the visual angle

As can be seen from the figure, when the visual angle decreased to $14.6'$, the right recognition percentage decreased significantly, only with 87.6%. To ensure the percentage of 90%, the minimal visual angle selected was $15.5'$.

(2) the legibility time based on 3D technology

To acquire the value of the reaction time, in-door simulation experiments were designed.

First define the time needed to find the direction of destination name in the sign as the legibility time. Through investigation the information which contains two or three Chinese characters made up the most percentage (7), so the information unit studied in this essay contained three characters. 153 Chinese characters with different strokes, structure and frequency were used. The number of information unit was from 2 to 10.

The 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 inserted 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 were added. At last, the car model was selected 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 actual scene of drivers recognizing signs.

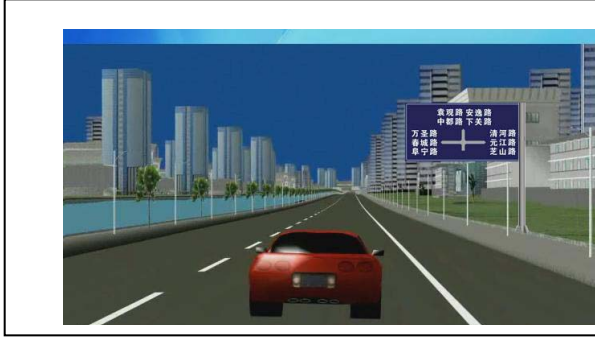


Fig 5 the scene of drivers recognizing signs

The software of E-Prime was used to display videos to the subjects. Subjects were given a destination road name at first, 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 requested to press a button, after comprehending the sign, subjects pressed another button to finish reading the sign. The experimenter then asked subjects the direction of the destination road, if the answer was right, it would be recorded otherwise discarded. Subjects continued with other video until the end. The results of the legibility time were automatically recorded in text.

The measured time contained a reaction time of the hand pressing button which should be deducted (8). The amending results of the legibility time were as follows.

Tab 1 the legibility time of signs

Information unit	2	3	4	5	6
Legibility time/S	1.256	1.506	1.351	2.047	2.430
Information unit	7	8	9	10	
Legibility time/S	2.911	3.485	3.772	4.378	

It could be seen that there was a close relationship between the number of information units and the legibility time. The legibility time increased as the number of information units increased. The growth of the legibility time was steady when the number of information units was less than 6 but when it exceeded 6, the legibility time increased dramatically. So we suggested the ultimate information of a sign be 6 information units, and the corresponding legibility time was 2.43s. To get a round number, 2.5s was selected.

(3) the disappearing distance $L_{\text{消失}}$

When cars travel at a certain distance away from the sign, the sign will be out of the visual field, and this point is defined as the disappearing point, the distance between the disappearing point and the sign is the disappearing distance (9).

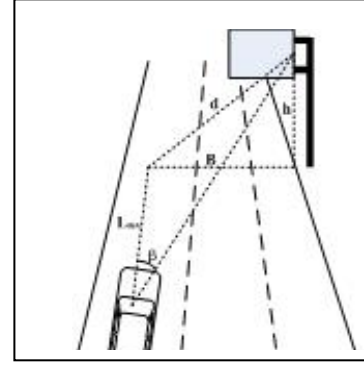


Fig 6 the disappearing distance

The following relationship could be built according to the geometric relationship:

$$L_{\text{消失}} = d / \tan \beta = \sqrt{H^2 + B^2} / \tan \beta \quad (4)$$

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

Referring to relevant study (10, 11): when the speed was less than 100km/h, β was 15° , when the speed was 120km/h, β was 11° . Taking the common two-lane roads in one direction as the example, by referring to Technical Standard of Highway Engineering (12), B is 10m, and H is 6.3m. The disappearing distance in different speed could be computed as follows:

Tab 2 disappearing distance $L_{\text{消失}}$

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

IV COMPUTATION BASED ON THE MODEL

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

$$H = (V \times 2.5 + L_{\text{消失}}) \times \alpha \quad (5)$$

Transform the visual angle $15.5'$ to radian measure, and the formula 5 was as follows

$$H = 0.004506 \times (2.5V + L_{\text{消失}}) \quad (6)$$

Substitute the disappearing distance in table 2 into formula 6, the results of character height H in various speeds were computed. The value computed by the model as well as that in national standard of signs (GB5768) were in table 3.

Tab 3 the character height in guide signs in different speeds

Speed (km/h)	120	100	80	70	60	40
Computed by model (cm)	64.8	51.0	44.8	41.7	38.6	32.3
Standard (cm)	60—70	60	50—60	40—50	40—50	40—50

V CONCLUSION AND OUTLOOK

This essay established the model of Chinese letter height. It will provide theoretic foundation for the letter height in the standard and play a big role in the traffic safety.

The following results could be reached based on the essay:

- 1) the ultimate information in guide signs is 6 units, and the corresponding legibility time was 2.5s;
- 2) the standards of the character height could be lowered but considering the safety redundancy it was appropriate;

The model was established in simulation experiments and it should be validated in dynamic vehicle experiment in the next step.

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