2010 3rd International Conference on Computer and Electrical Engineering (ICCEE 2010)
IPCSIT vol. 53 (2012) © (2012) IACSIT Press, Singapore
DOI: 10.7763/IPCSIT.2012.V53.No.1.81

Research on Evaluation Method of Vehicle Head-Lamp Follow-Up Steering Control System Based on Virtual Scene

Pengchao Du[1, 2, 3+] , Wei Liu[3], Weibin Lu[3] and Tao Zhang[3]

[1] Hefei Institute of Intelligent Machines, Chinese Academy of Sciences
[2] Universities of Science and Technology of China
[3] Institutes of Advanced Manufacturing Technology, Chinese Academy of Sciences, Heifei, Anhui, China

Abstract. The application of the vehicle head-lamp follow-up steering control system (VHFSCS) significantly improves the lighting environment for drivers, which makes it safer to drive on curved roads at night. In order to help the engineer in optimizing the control strategy of VHFSCS, it is important to conduct a method to evaluate and validate VHFSCS when it is working. The method presented by means of visual scenes, neural networks and fuzzy systems in this paper consists of three parts: virtual scene modes, virtual modules and evaluation model. Evaluation result can be derived by interactive behaviors between the virtual vehicle and virtual modules. This method makes it possible to evaluate and validate VHFSCS, and optimize the Control Strategy.

Keywords: virtual scene; validation and evaluation; head-lamp follow-up steering control system; neural network; fuzzy system

1. Introduction

By collecting vehicle motion parameters, VHFSCS can adjust the direction of headlight in real-time to provide a good night lighting environment. Researches show that dynamic lighting adjustment can improve the illumination up to 50%. Also it can make drivers focus much more on driving [1, 2]. Therefore, more and more VHFSCS are used in the vehicles. In this case, how to evaluate control effect of VHFSCS becomes notable. This problem plays an important role in optimizing control strategy of the VHFSCS.

So far, few researches are done on evaluation and validation of the VHFSCS. Most of them concentrate on the distribution of light but less on the whole system [4]. In this paper, lots of work is done to analyze the functions and significance of head-lamps to ensure that all the virtual modules chosen are reasonable. As the complexity of calculating flare had been overcome, a platform based on virtual scene is established. This platform provides a method for engineers to evaluate and validate the control strategy, which can be used to optimize the control strategy. Virtual scene can not only simulate real environment but also has advantage of flexibility, economy, safety and freedom from time and space conditions.

As shown in figure 2, the platform introduced in this paper is mainly composed of two subsystems: virtual scenes subsystem and input signal subsystem. Virtual scenes subsystem is used to provide virtual vehicle and environment for validating and evaluating the control strategy. Among those, virtual environment includes traffic environment, road forms, road surfaces, traffic markings and roadblocks. Signal input subsystem can afford various analog signals to drive the platform work. In the course of establishing virtual scene, vehicle dynamic model and friction coefficient of the road should be paid enough attention, so that the scene can provide information as much as possible.

[+] Corresponding author.
E-mail address: pcdu@mail.ustc.edu.cn

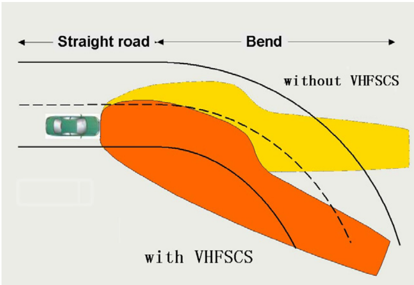

Figure 1 Effect of VHFSCS [3]

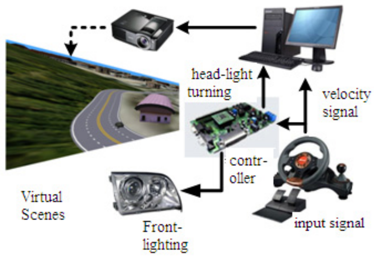

Figure 2 Sketch map of the platform

2. Framework of the Virtual Scene

As the development of the virtual scene and artificial intelligence, establishing a virtual scene with intelligent behavior provides a new way to valuate the control strategy of the VHFSCS. How can we establish an effective evaluation model? How can we use it practically? All these questions request that the virtual scene needs flexibility and pertinence. Actually, virtual scene must adapt the diversification of the testing focus. For example, if one designer wants to test the influence by turning radius on the turning angle of the Head-Lamp, virtual scene should provide corners with a serial of radii. If one wants to test lighting conditions of traffic markings, virtual scene should provide various traffic markings and road modules.

Figure 3 shows the framework of the virtual scene. System tested is the electric control unit of VHFSCS, which is the object of the test. Analog input unit provides kinematical parameters of vehicle and drives system tested and virtual scene. Vehicle module (length of vehicle, distance between the axle and the body, distance between the two lamps .etc) can be initialized based on the type of vehicles. And road module, height of Pedestrians, volume of roadblocks must be realized seriation to be chosen. In addition, all modules can be removable. The whole system works as follows: 1, initialize virtual vehicle based on the type of the vehicle; 2, choose virtual scene module according to the purpose of testing; 3, input analog signals to the drive system; 4, record the data of the test index and calculate evaluation result.

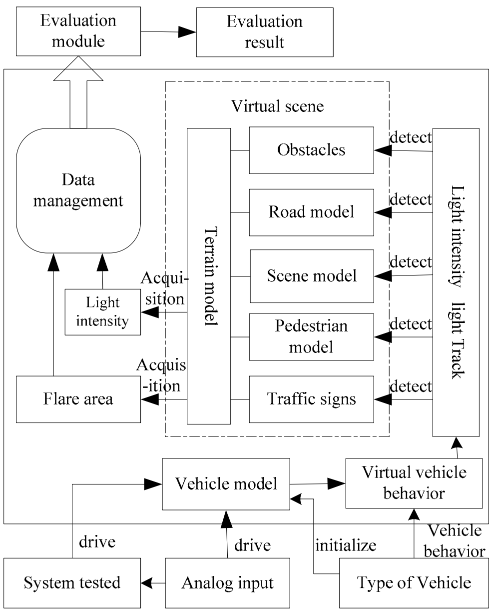

Figure 3 Framework of virtual scene

3. Construct the Virtual Scene

When investigating the method of constructing virtual scene, it is important that what modules used to validate and evaluate control strategy should be chosen and what episodes should be used, which make the interaction occurs between the virtual vehicle and virtual modules. These interactive behaviors can afford effective data source for validation and evaluation. Thus, objective and accurate evaluation results can be derived.

In order to choose modules used to validate and evaluate control strategy, it should be clear that what is useful to improve safety when driving and what factors probably cause traffic accidents. Please rewrite. Some useful information is as follows: 1. illumination range and irradiation distance; 2, geometries of the road; 3, traffic markings; 4, road conditions; 5, crossroad; some adverse factors include roadblocks, pedestrians (animal included) and the bad weather (will not be considered in this paper). Besides, in consideration of the difference of friction coefficient of road and road conditions, virtual scene has three modes: highways, city streets and country roads [5]. Thus, pedestrians, roadblocks, traffic markings, geometries of the road and crossroads are chosen as evaluation modules.

3.1 Virtual scene modes

As table Ⅰ shows, virtual scene has three modes: highway, city street and country road. In highway mode, the speed of vehicle is very high. Friction coefficient of road is high and there is no crossroad. In contrast, vehicles move slower in city street mode, friction coefficient of road is the smallest. Finally, friction coefficient of country road is least, vehicles sideslip easily, In addition, these are too many S shaped and U shaped roads.

Table Ⅰ Virtual Scene Modes

environment	Road conditions	Lane line	crossroad
Mode 1	highway	yes	no
Mode 2	city streets	yes	yes
Mode 3	country road	no	yes

3.2 Pedestrians and roadblocks

Due to autonomy and nondeterminacy of pedestrians, driver must find pedestrians and react timely to prevent traffic accident. In consideration of driving environment and reflection coefficient, a pedestrian 30m away is chosen as a test module [6]. Based on the height of light projected on the pedestrian, evaluation results can be divided into four grades shown in table Ⅱ.

Table Ⅱ Evaluation result Grades of Pedestrian

Evaluation standard	Grade
Non-visible	0
Existence recognizable	1
Visible up to waist	2
Visible up to head	3

3.3 Traffic marking

Traffic markings provide lots of information for drivers to drive safely. Thus, it is significant that some representative traffic markings exist in the virtual scene. Based on the height of light projected on the traffic marking, evaluation results can be divided into five grades.

Table Ⅲ Evaluation Result Grades of Traffic Marking

Evaluation standard	Grade
Non-visible	0
Existence recognizable	1
Visible up to middle part	2
Visible up to top but obscure	3
Visible up to top and clear	4

3.4 Geometries of the roads

As Figure 4 shows, the geometries of the roads are selected S-type, T-type, cross-shaped, U-type, line type and so on. Among those shapes, S-type and T-type roads need to be in serials, that is to say, these shapes have various radii. S-type road, it is easy to test coherence of VHFSCS. Also, by testing the difference of control effects caused by the fact that the two lamps turn in the same or direction, influence on control effectiveness by the respective direction of movement becomes clear [7].

Figure 4 Geometries of the roads

4. Evaluation Method

4.1 Choosing evaluation index

It is important that evaluation indexes are reasonable enough to reflect the significance of the existence of vehicle headlamps, that is to say, automobile headlamps can afford good lighting conditions which are beneficial for finding various information and unexpected states for drivers. In addition to this, humanization of the control system should be considered. With the significance of headlamps as a starting point and taking hommization into account, evaluation indexes are chosen as follows: illumination range, illuminate intensity, real-time properties of headlight movements and visibility of traffic markings, roadblocks and pedestrians.

To evaluate of illumination range, only useful light is taken into account to calculate the illumination acreage, which is projected on the road, as shown in the figure 5. Acreage in the red polygon is the valid part.

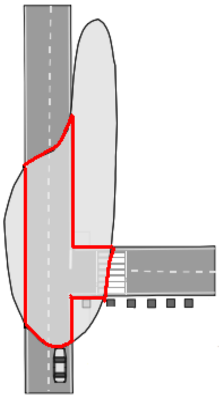

Figure 5 Valid illumination range

Calculating illumination intensity is a key point of the evaluation, which is also difficult. As shown in figure 6, a light column is created in Multigen Creator. Acreage of S stands for illumination range. Similarly, d stands for the illumination height of the module (pedestrian, roadblock, traffic marking). Illumination intensity of a point can be presented by the distance between the vertex and the test point. Illumination intensity of a surface is the average of Illumination intensity of all points which can be done by surface integral.

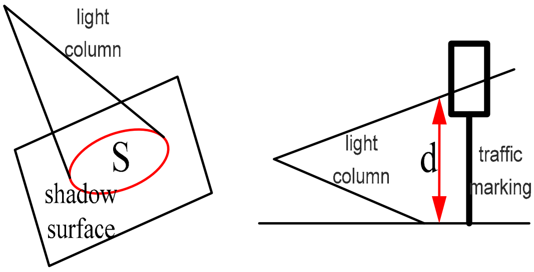

Figure 6 Illumination range and illumination height

Due to the continuity of the illumination intensity, although that evaluation of pedestrian, roadblock, and traffic marking have been divided into several grades, evaluation results can not be obtained simply according to those grades. Then, this paper takes evaluation of traffic markings for example to analyze derivation process. In this process, sensitization points A, B are introduced. A is at the middle of trestle of traffic marking. B is in the center of traffic marking. Fuzzy subset of A and B points about illumination intensity is {NS, ZO, PS} (NS= Non-visible, ZO=Visible but obscure, PS= Visible and clear). Quantization level is {0，1，2，3}. K_X is the quantization factor. Subordinate Function of input/output is equilateral triangle, which is shown in figure 7. Table Ⅳ is fuzzy rules.

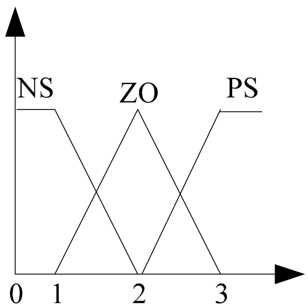

Figure 7 Subordinate Function of input/output

Table Ⅳ Fuzzy Rules

A \ B	Non-visible	Visible but obscure	Visible and clear
Non-visible	Non-visible	Existence recognizable	Existence recognizable
Visible but obscure	Existence recognizable	Existence recognizable	Visible but obscure
Visible and clear	Visible up to middle part	Visible but obscure	Visible and clear

Based on tableⅣ, rule intensity can be derived and evaluation results can be calculated with equation (1);

$$u = \frac{\sum_{1}^{l} \omega_i \times z}{\sum_{1}^{l} \omega_i} \quad (1)$$

u: evaluation result, ω_i: rule intensity, z: result of corresponding rule shown in table 3, *l*: number of rues

4.2 Establishing evaluation model

If evaluation indexes and single evaluation result have been determined, neural network is an effective tool to realize data fusion and derive evaluation results of the whole system finally. In this course, expert database is introduced. According to different combination of single modules illuminating effect, excellent driers give a point to control system. All of those results exclusive of singular points and ineffective points constitute the expert database, which is used to train the neural network.

A neural network with deviation, at least one S-Type hidden layer and linear output function can approximate any rational functions in theory. Increase of the hidden layer can reduce error and improve accuracy, but complexity of the neural network is increased. Besides, it will take a longer time to train the neural network. With comprehensive consideration of above factors, a "6-10-1" B-P neural network is selected as the evaluation model shown in figure 8. Input value is single module evaluation result of turning speed of head-lamps, traffic makings, roadblocks, illumination range, illuminate intensity and pedestrians. Output value is the evaluation of the whole system.

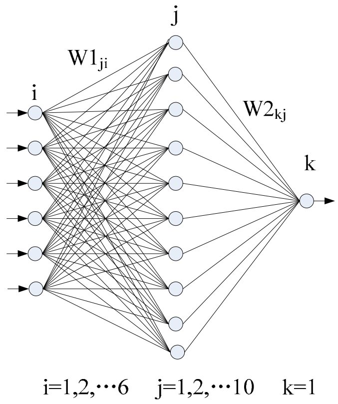

Figure 8 Neural network of evaluation model

$$T=W2*W1*P \quad (2)$$

P: input vector, T: output vector, W1, W2: weight matrix

5. Conclusion

The model presented in this paper realizes quantization of evaluation, which makes evaluation results avoid being interfered by subjective factors. This model can be used to optimize the control strategy of the system. Also, it can be used in other traffic behavior tests flexibly because of its integrity and modularization. As the model is not very consummate, further research should be continued to improve the evaluation model.

6. Acknowledgment

This work was supported by the National Natural Science Foundation of China under Grant Nos.50908222.Thank Yi Ding for the revise.

7. References

[1] Grimm M. "Improved Nighttime Visibility for Drivers through Dynamic Bend Lighting", Proceedings of Progress in Automobile Lighting. Darmstadt, Germany: 2001

[2] Yuichi Shibata, H.-J. Schmidt-Clausen, Carsten Diem, "The Evaluation of AFS Beam Pattern using the Movement of the Driver's Eye-Fixation Points", 2006 SAE World Congress, Detroit. Michigan, April, 2006

[3] Detlef Decker,Andreas Himmler,Christian Amsel, "The Road to Active Light – Headlamp Concepts with Enhanced Adaptive Functionalities", SAE 2007 World Congress, Detroit.Michigan, April , 2007

[4] Alexander von Hoffmann,"Evaluation of Adaptive Light Distributions with AFSim",SAE 2001 World Congress, Detroit. Michigan, USA,2001

[5] LIU Xin,MEI Tao,ZHANG Tao, "Research of Virtual Scene for Validation and Evaluation of Vehicle's Intelligent Behavior", Journal of system simulation, 2009, 21(24): 7821-7823

[6] Masao Okawa, "The Development of Visibility Evaluation Method for Automotive Headlamps in Motion", 2003 SAE World Congress, Detroit. Michigan, March,, 2003

[7] Alexander von Hoffmann, "Evaluation of Adaptive Light Distributions with AFSim", SAE 2001 World Congress.Detroit, Michigan, USA,2001