Comfortable Driver Behavior Modeling for Car Following of Pervasive Computing Environment[1]

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Abstract. This paper demonstrates a novel car-following model based on driver or passengers' comfort. As we know, hasty deceleration during emergency brake will cause passengers feel uncomfortable. According to the relationship between brake acceleration and people's comfortable feeling, the comfortable model is setup. The model calculates the following car's acceleration by measuring the distance between the following car and the preceding car, the velocity of the following car, and controls the car's acceleration to make driver and passengers feel comfort. The paper combine the model with the pervasive computing concept, provoke the pervasive computing driver behavior modeling idea and turn it into reality to increase the adaptability and reliability of car's parts, when car equipped with this device, the prospect is not only the assistant driver or comfortable driver are realized in the car-following circumstance, but also the whole car's performance will be improved.

1 Introduction

The idea of pervasive computing is developing to be one of the hottest research topics at present [1]. The academic circles of all countries already have great foresight to focus on the research of the related topic [2].

The researches on driver behavior modeling have developed following mainly directions in recent years, the driver performance and capacity [3], the longitudinal driver behavior [4] and driver skill. The driver performance and capacity include mental and physical researches. There have been made a huge progress in all the directions these years [5].

Most of the early works in car-following model [6], PD-controller car following model [7], and visibility angle model [8] [9] are that drivers react immediately to the behavior of the vehicle in front of them so as to avoid imminent accidents. This paper focus on the driver's comfortable of car following.

Actually there can be as many as 50 embedded computers inside a modern car, on the other hand, a general human drivers behaviors is inherently complex. Both the

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car's researches and driver behaviors modeling can not be separate from using as many as computing techniques, the pervasive computing must take an important roles in future research of them.

2 A Comfortable Car-Following Model

2.1 A Car Following Model Based on Space and Velocity

Car following model describes the driver longitudinal behavior shown as in Fig.1.

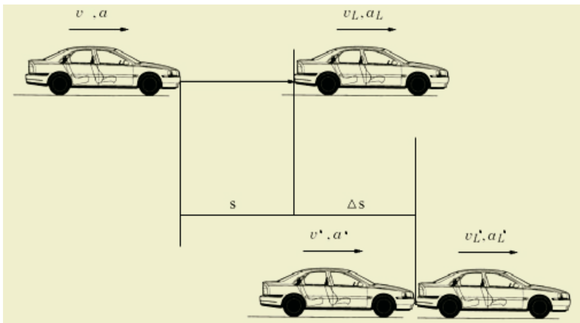

Fig. 1. Car following model based on space and velocity

At the time of collision, to the following car there is relation:

$$2a(s+\Delta s)=(v'^2 - v^2) \quad (1)$$

For the worst condition, above equation can be simplified as following:

$$2as=v^2 \quad (2)$$

2.2 Comfortable Car Following Model Based on Acceleration

The acceleration a can be calculated from s and v according to formula (2). Of the different a, the comfortable status are shown as table 1, the a_c represent the critical comfortable acceleration, the researches show that its value is 2 m/s^2.

Table 1. The following car's status of comfortable car following models

Area	Condition	Acceleration
Comfortable	$s > v^2/2a_c$	$a < a_c$
Uncomfortable	$v^2/2a_{max} < s < v^2/2a_c$	$a_c < a < a_{max}$
Dangerous	$s < v^2/2a_{max}$	$a > a_{max}$

2.3 The Realization of Comfortable Driver Behavior Model

Actually, the minimum brake distance $s_{\min}$ is related to the car's velocity, the car's velocity, and the friction coefficient of road surface. An experience formula of the relationship is shown as:

$$s_{min}=v^2/(2\mu g) \quad (3)$$

When considering the boundary conditions and friction coefficient, the relationships among *a, s, v, μ* are shown as Fig.2.:

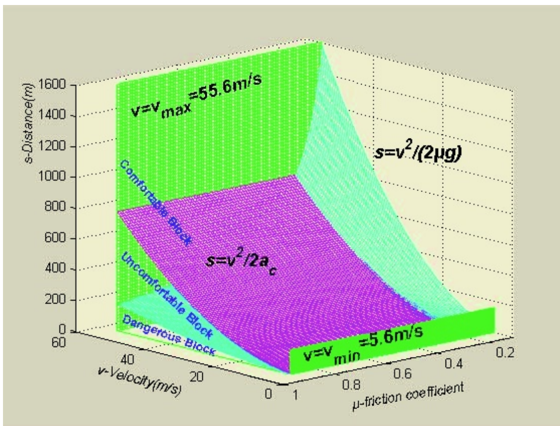

Fig. 2. The relationship among *s*, *v*, *μ* and *a*

The surfaces in Fig.2.enclosed several blocks, they are represent different physical conception, we named the relevant blocks as Table 2.

Table 2. The following car's status of comfortable car following models with COF

Block	Enclosed by	Acceleration
Comfortable block	$s > v^2/2a_c$, $s > v^2/2\mu g$, $0.2<\mu<0.9$, $v_{min}<v<v_{max}$	$a < a_c$
Uncomfortable block	$s < v^2/2a_c$, $s > v^2/2\mu g$, $0.2<\mu<0.9$, $v_{min}<v<v_{max}$	$a_c < a < a_{max}$
Dangerous Block	$s < v^2/2\mu g$, $s=0$, $0.2<\mu<0.9$, $v_{min}<v<v_{max}$	$a > a_{max}$

3 Implementation Driver Behavior Modeling of Pervasive Computing Environment

A wireless speed sensor is equipped to obtain the car's velocity, a *Bushnell Yardage Pro 800 Compact Rangefinder* displacement device is installed to detect the distance, and a dynamic friction coefficient tester is used to determine the friction coefficient.. The architecture of the model of pervasive computing environment is shown in Fig. 4.

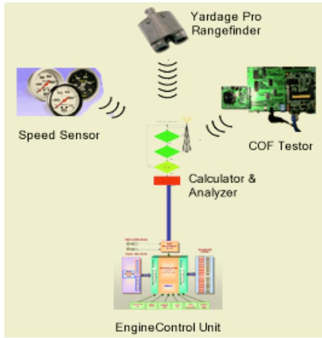

Fig. 4. The architecture of the comfortable model in pervasive computing environment

4 Experiments and Conclusions

The experiments are implemented by using a BUICK REGAL 2.5 car of GM, and the car running on a dry road surface of a highway on a sunny day.

One contribution of this paper is to demonstrate a new car-following model based on driver's comfort, while most of the former models are contribute to the safety of the car or the traffic flow throughput.

Another contribution is the introduction of pervasive computing conception to the drivers' behavior modeling researches. The paper combines the drivers' model with the pervasive computing concept, and makes the model as a pervasive computing device into reality to increase the system's adaptability and reliability.

References

1. Xu Guangyou ,The ubiquitous pervasive computing. China computer, June 9, 2003 general issue number 1222, year issue number 41.
2. Xiong Jiang, Embedded system and pervasive computing.
3. Strategies for Reducing Driver Distraction from In-Vehicle Telematics Devices: A Discussion Document (June 2003), Transport Canada TP 14133 E.
4. Driver Behavior Models for Traffic Simulation, Xiaopeng Fang, thesis of Iowa State University,2001
5. Yoshiyuki Umemura,Driver Behavior and Active Safety (Overview),Special Issue Driver Behavior and Active Safety,R&D Review of Toyota CRDL Vol. 39 No. 2
6. Johan Bengtsson, Adaptive Cruise Control and Driver Modeling, Printed in Sweden,Lund University, Lund 2001
7. Xiaopeng Fang, Hung A. Pham1 and Minoru Kobayashi, PD Controller for Car-Following Models Based on Real Data
8. Pipes, L.A. and Wojcik, C.K., A contribution to theory of traffic flow, SAE Conference Proceedings – Analysis and Control of Traffic Flow Symposium,(Detroit, 1968), pp. 53-60
9. Ir. J.J. Reijmers, Traffic Guidance Systems, November 26, 2003 Et4-024 P99