Development and evaluation of ISA to solve the traffic-safety problems in Kagawa prefecture

Kan Nakada , Seunghee Hong , Keisuke Suzuki

Faculty of Engineering, Kagawa University

Abstract

In this study, we developed Intelligent Speed Adaptation (ISA) system which can solve some traffic problems in Kagawa prefecture. One of the problems concerning traffic-safety in Kagawa prefecture is the pedestrian-car accident and the bicycle-car accident at intersections and the exceeding speed on a road. Therefore, we constructed ISA to solve this problem. This system gives information to the driver by using a GPS when the vehicle exceeds the speed limit or gets close to an intersection. The improvement of driving behavior in terms of preventive safety can be expected in using this system. We conducted a demonstration experiment which use real vehicle on a public road, to verify the effectiveness of the system. Throughout this experiment, we optimized the method of giving information to the driver on the monitor and the beep sounds and clarified characteristics of driver and traffic environment which show significant effectiveness on improving the driving behavior.

Key Words: Intelligent Speed Adaptation (ISA), Advanced Safety Vehicle, Intersection, Zone-30, DSQ, Driving Style

１. Introduction

Kagawa prefecture has some traffic safety problems. One of the problems is the pedestrian-car accident and the bicycle-car accident at intersections and on community roads. To solve this problem, the project named the Zone-30 which limits a running velocity to 30km/h at a community road and near a school etc. is focused on in this study. In Japan, the police agency is promoting the Zone-30 project. Its method of introduction and acceptability has already reported. For example, "Research review committee of the zone measured at community road"[1] reported that changing road specifications have effects on decreasing a running velocity and proposed the concrete way to set up limited areas. But it's too difficult to change the road specification in a narrow road. In addition, a running velocity is far higher than speed limit in Japan. Accordingly, if the police agency simply set up limited area, it's assumed that driver exceeds the speed limit. Therefore, it's hoped that the device which controls the running velocity within 30km/h is mounted to vehicles. For example, Intelligent Speed Adaptation (ISA) which operates to control velocity within speed limit of each traffic environment by presenting information regarding speed limit to the driver or controlling a gas pedal when the vehicle exceeds the speed limit. It's already reported that introduction example about same concept by Oguri[2] and Suzuki[3] et al.

In this study, we constructed ISA of Kagawa version which can solve traffic-safety problems of Kagawa prefecture related to the accident of pedestrian-car and bicycle-car. Therefore, we conducted a demonstration experiment on a public road to evaluate the effectiveness of the system. The detail is shown below.

[1]Constructing ISA of Kagawa version which presents information to driver when the vehicle exceeds the speed limit and approaches intersections.

[2]Evaluating ISA of Kagawa version through the experiment in various traffic environment.

[3]Defining the driver characteristics and traffic environment which show significant effectiveness on improving the driving behavior.

[4]Optimizing the method for presenting information regarding the speed limit and approaching to the intersection in consideration of HMI.

2. Experimental method

2.1 ISA device

Fig.1 shows the configuration diagram of Kagawa version ISA.

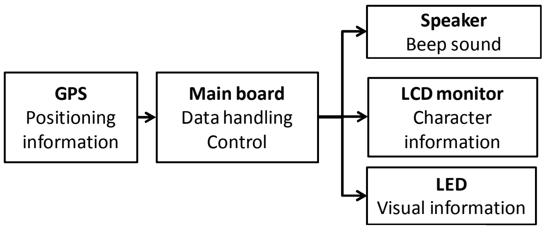

Fig.1 The configuration diagram of ISA

The system detects own position and velocity based on a GPS position data. The sampling rate of a GPS is 1sec. The own velocity is detected based on a distance which is obtained by comparing current GPS data with the last one. The system also detects the distance between own position and intersection from comparing the position of a GPS with intersection position which preprogrammed in the system. When the vehicle exceeds the 30km/h, the system presents character information such as “Slow down!! ” on a LCD monitor and alarms to driver with beep sounds or a LED lighting until the velocity becomes under the 30km/h . And when the vehicle gets close to an intersection within 50m (It’s assumed Time To Collision (TTC) is 3sec), the system gives information to the driver by character information such as “Watch for the intersection” and beep sounds or lighting a LED in one second. Fig.2 shows the method of giving information.

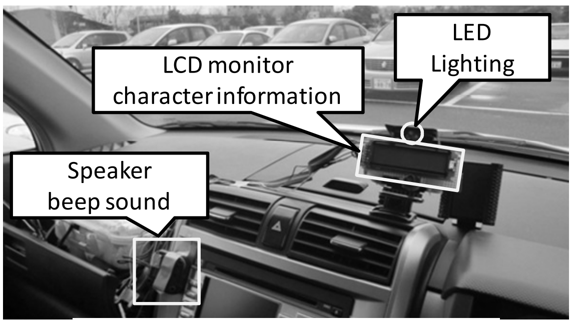

Fig.2 The method of giving information

It’s one of the features that this device doesn’t depend on the vehicle regarding the power supply or speed signal and all. We think that this feature is very important to make this device becoming common to reduce the traffic accident.

2.2 Experimental protocol

We have carried out a demonstration experiment using the Kagawa version ISA on a public road. The experimental course is constructed with four roads which have different traffic environment. These roads are supposed to be in the area of the Zone-30. Fig.3 shows the characteristics of each road.

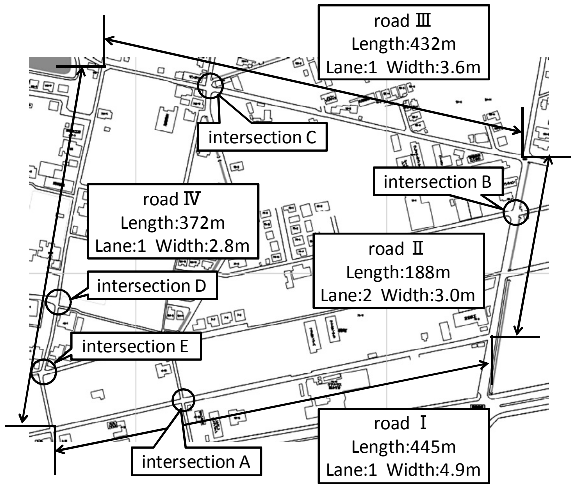

Fig.3 Specifications of the roads

We focused on the five intersections where the system gives information to the driver. These intersections also have different environment. Fig.4 shows the scenery from a driver of each intersection.

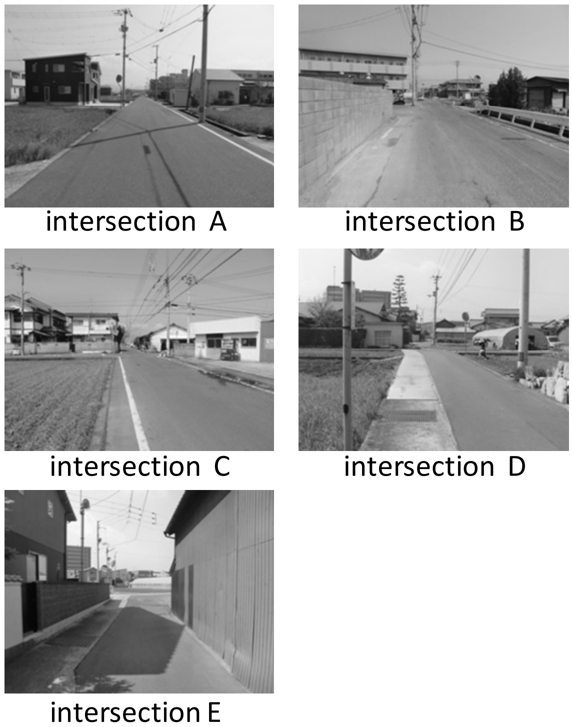

Fig.4 Scenery from a driver of intersections

The experimental condition is following three.

Condition 1 : Without system

Condition 2 : Giving information by beep sound and character information

Condition 3 : Giving information by LED and character information

2.3 Evaluation method

(1) State quantity

In this experiment, we used the data-logger to obtain the running velocity, position and so on. We detected the intersection speed and the cruising speed based on data by using data-logger. The intersection speed is the velocity at a center of an intersection. The cruising speed is defined that the average velocity is higher than 20km/h.

(2) Characteristics of driver

We use the DSQ[4] as an evaluation method regarding characteristics of driver. The DSQ evaluates the driving style by using questionnaires. We clarified the characteristics of driver that the system works very effective or ineffective by using the result of DSQ and the State quantity.

(3) Acceptability of the system

We asked the driver to answer the questionnaire after running to evaluate acceptability of the system. Through this questionnaire, we evaluate the understandability of the information, the irritation and the occasion regarding the system.

2.4 Test subject

We got the informed consent regarding device, course and etc. to the test subject. Test subjects were five male university students (mean age ± SD : 22.6±1.1 years old).

3. Result of the experiment

3.1 Intersection speed

Fig.5 shows one of the experimental data recorded by a data-logger. The x-axis is a position of running. The y-axis is running velocity. The running velocity was the lowest in a condition of the beep sounds. In a condition of the LED, running velocity was lower than without the system, but it was higher than that in a case of the beep sounds. A decrease in speed was confirmed at intersections in a condition of the beep sounds.

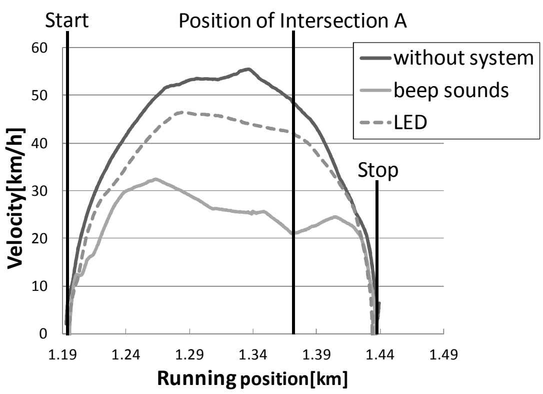

Fig.5 Experimental data recorded by a data-logger

Fig.6 shows the average of the intersection speed among five test subjects. In a condition of the beep sounds, the velocity was within 30km/h at all intersections. In a condition of the LED, the velocity exceeded the 30km/h at intersection A and B, but the velocity was slower than the result without system. We carried out the t-test that is one of the test about the difference of average value between the beep sounds and the without system. As a result, the significant difference ($P<0.05$) was clarified regarding the intersection A and D. The detailed discussion regarding an intersection speed is described in section four.

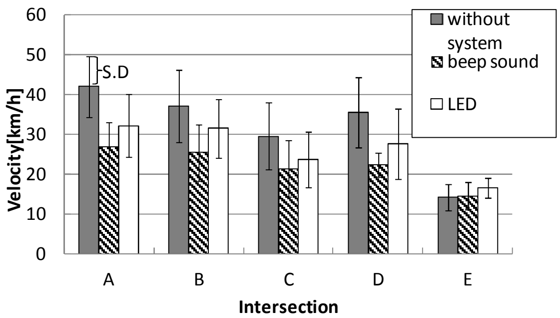

Fig.6 Intersection speed

3.2 Cruising speed

Fig.7 shows the average of cruising speed among five test subjects. Concerning the cruising speed, the tendency regarding the decrease in velocity by the system was confirmed. Through the t-test between without system and the beep sounds, We clarified the significant difference except for road II. The detailed discussion regarding this tendency is described in section four.

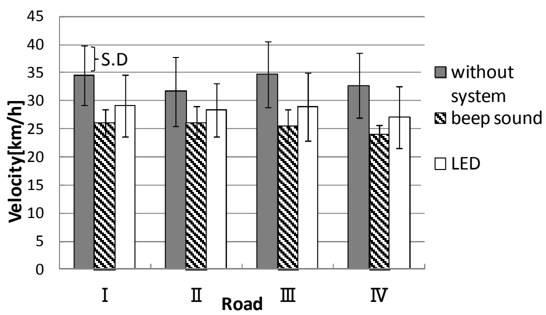

Fig.7 Cruising speed

3.3 Characteristics of driver

Fig.8 shows the result regarding DSQ of test subject #d that the system shows the significant effectiveness on the driving behavior. Fig.9 shows intersection speed of test subject #d. DSQ showed that this driver has impatience driving style and Fig.8 shows the intersection speed was high in a case without system. In a condition of beep sounds, the system showed high effectiveness.

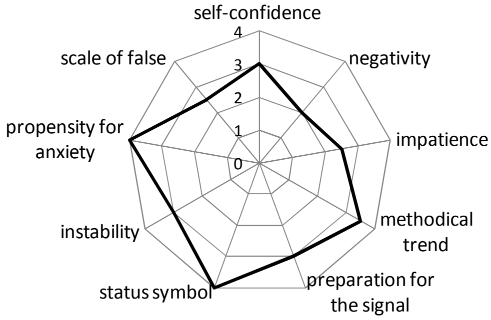

Fig.8 Result of DSQ regarding test subject #d

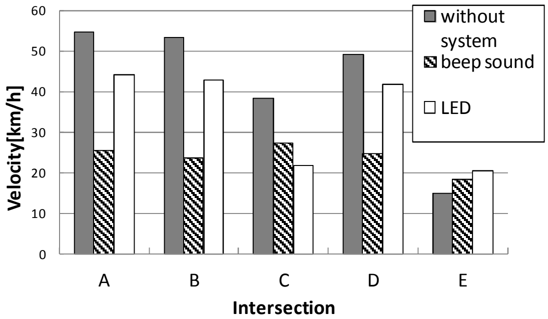

Fig.9 Intersection speed of test subject #d

Fig.10 shows the result regarding DSQ of test subject #b that the system did not work effectively. And Fig.11 shows intersection speed of #b. DSQ showed that this driver has methodical tendency and propensity for anxiety tendency. Especially, the system efficiency was very low at intersections with good visibility and wide environment.

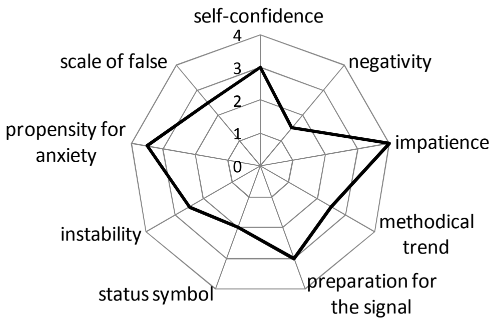

Fig.10 Result regarding DSQ of test subject #b

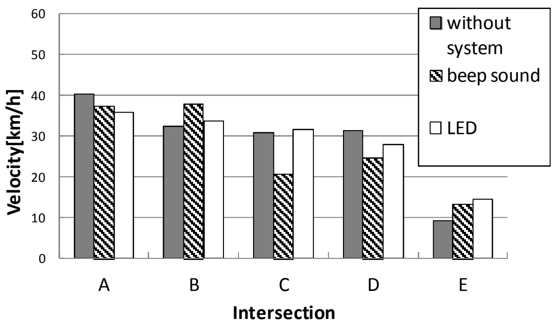

Fig.11 Intersection speed of test subject #b

3.4 Acceptability of the system

The questionnaire regarding acceptability of the system showed that the high acceptability is shown in road III and IV which have a poor visibility and a narrowness. In terms of the method of the giving information, the beep sounds were easy to be understood but very intrusive. In contrast, the LED was difficult to be understood but it's not intrusive.

4. Discussion

It's confirmed that the system makes the velocity slow in a result of Fig.6 and Fig.7. Specifically, average of the intersection speed was under 30km/h in a condition of beep sounds. Therefore it is thought that this system has high effectiveness of driving behavior in the Zone-30 environment. The reason of this, beep sounds are very intrusive, and the driver drives in a low velocity not to hear beep sounds. In the LED condition, the velocity was lower than that without the system. But it's higher than that in the beep sounds condition. It is because that the LED is affected by the brightness of ambient and it's not intrusive than beep sound. In terms of traffic environment, this system showed high effectiveness at a good visibility environment than a poor visibility environment. It's because that the driver tends to pay attention to the environment with poor visibility if a vehicle doesn't have the system. But in a road with good visibility, the driver doesn't mind the speed, pedestrian and the other thing than poor visibility road. It's reported about the relationship between the peripheral visual functions and the cause of accidents in a good visibility road by Uchida[5] et al. Also it is proposed that the device to prevent such accident using vehicle-to-vehicle communication by Katayama[6] et al. In Kagawa prefecture, it's reported that some accidents happened in the similar environment[7]. Therefore, this system is hoped to prevent these accidents and to reduce damage of accidents.

Regarding the characteristics of driver, it's showed that the driver who has impatience on own driving style drives vehicle fast in normal, therefore the system shows high effectiveness. The driver who has methodical tendency and propensity for anxiety tendency is thought that the driver dislikes an interposition of the system and keeping the own pace. Therefore, it's thought that the system does not work effectively. In this experiment, there isn't enough data regarding characteristics of driver because the number of test subjects is small. Therefore, it's necessary that increasing the number of test subjects and clarifying the relationship between effectiveness of the system and characteristics of driver.

In terms of acceptability of the system, the road III and IV which have poor visibility and narrow width showed high acceptability. The road with good visibility and large width showed low acceptability. Kagawa prefecture has many traffic accidents in these environments that a vehicle often runs at high velocity. Therefore it's necessary to enhance the acceptability and effectiveness in this environment. In terms of the method of the giving information, the LED was more acceptable and less intrusive than the beep sounds. But the beep sounds were more effective than the LED. It shows that the irritation of the giving information makes the system more effective, but the acceptability becomes low. Therefore the balance of these two aspects is very important. There is an opinion that the beginner driver likes beep sounds than a LED. It's necessary to construct the designing guideline for giving information taking account of characteristics of driver.

5. Conclusion

In this study, we constructed the Kagawa version ISA to solve the traffic accidents regarding the pedestrian-car accident and the bicycle-car accident in Kagawa prefecture. And we evaluated the effectiveness of the system through an experiment on the public road. The conclusions are shown below.

[1]Constructed the Kagawa version ISA system by using GPS.

[2]Confirmed the effectiveness of the system regarding decreasing speed through a demonstration experiment.

[3]Suggested the characteristics of driver and traffic environment which system shows high effectiveness based on the data of an experiment. The driver who has an impatience driving style shows high effectiveness of the system. In contrast, the driver who has methodical tendency and propensity for anxiety tendency shows low effectiveness of the system. And in terms of traffic environment, the roads with good visibility and large width show high effectiveness of the system.

[4]Obtained the characteristics of beep sounds and a LED for the method of giving information by using questionnaire. The beep sounds showed high effectiveness, but they were very intrusive. Therefore, they showed low acceptability. In contrast, the LED showed lower effectiveness than the beep sounds. But it showed high acceptability because of low intrusive.

The future subjects are shown below.

1. Increase the number of test subjects

In this experiment, we had five test subjects but it is not enough. It's necessary that getting more data to analyze more closely by the additional experiment. And also taking account of raising the number of elder driver, we will conduct the experiment among the elder driver. Through this experiment, we will make a comparison between elder driver and the others regarding the difference of driving behavior and effectiveness of the system. And we will construct the specialized system especially for elder drivers.

2. Refining the HMI

This experiment shows the necessarily of refining HMI. We will construct more effective and more acceptable device. In terms of hardware, we adjust the beep sounds and a LED regarding HMI through the experiments by using driving-simulator or real vehicle. In an aspect of software, we will make an algorithm to construct the HMI on the basis of the personal characteristic.

Reference

[1] Research review committee of the zone measure at community road : The report of the zone measure at community road 2011

[2] Yukio Oguri : Development of Soft Q Car (Electric Vehicle with Maximum Speed Control and Indication) and Its Implication for ITS Policy. *IPSJ SIG Technical Report*, 2008-ITS-32

[3] Keisuke Suzuki : Intelligent Speed Adaptation Project in Sweden. *JARI Research Journal*, Vol.23, No.7, PP.20-23, 2001

[4] Motonori Ishibashi , Masayuki Okuwa , Motoyuki Akamatsu : Development of Metrics for Driver's Individual Characteristics. *Mazda Technical Review,* Vol.22, PP.155-160, 2004

[5] Nobuyuki UCHIDA and Tsuyoshi KATAYAMA : Peripheral visual functions and cross traffic intersection accidents. *Japanese Psychological Review*, vol.44, No.1, PP.37-46, 2001

[6] Tsuyoshi Katayama , Hiroshi Hashimoto , Zhengrong Yang : Traffic Accidents in Rural Area and Assist System for Traffic Safety. *Journal of Society of Automotive Engineers of Japan Vol.5*, No.7, PP.42-47, 2000

[7] Kagawa police http://www.pref.kagawa.jp/police/data/koutsujiko/h24.html