Beginner Driver Support System for Merging into Left Main Lane

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Abstract. On Japanese high-ways, sharp turn and merging areas are the critical points where the majority of accidents occur. A number of studies have therefore taken place to date on supporting safer driving in merge areas within a framework of Intelligent Transportation Systems (ITS). Most of these studies, however, have assumed that drivers merge into the right main lane from the left lane because it is natural for Japanese drivers to do so, and in actuality those merge areas being rather prevalent in Japan. On actual roads, due to restrictions crossroads or the geographical conditions areas where drivers merge from the right lane into left main lane are also present. Cars in Japan are right wheel drive, thus it is difficult for a driver in a right driver's seat to monitor what is behind on the left. Monitoring left rear involves the motion of turning the body to the left, and at worst, a wheel turn to the left. This may cause a collision with other cars and, even if it is does not result in an accident, a stop or a slowdown, obstructing the following traffic. Beginner drivers find it particularly difficult to merge into the left lane. In this study, we suggest some technical skills that can be of support to beginner drivers when merging into the left main lane. As future work, we discuss a new driver support system that utilizes road-to-vehicle communication equipment via CCD-camera.

Keyword: ITS, merging, main lane, driver support system.

1 Introduction

On Japanese high-ways, sharp turn and merging areas are especially dangerous spots where the majority of accidents occur [1]. Research on support of merging into main lanes has therefore taken place in the past. However, most of that research has involved the expectation that drivers would be merging into right main lane from the left with the reason that vehicles drive on the left in Japan. And in actuality that road structure is quite general. However, actual roads have areas where merging also takes place into the left main lane due to the restriction of crossroads or the situation around them. Right-hand driving makes it difficult for Japanese drivers to check behind them on the left, which is important when merging into main lanes as it can result in other cars having to slowdown or stop and thereby obstructing the smooth flow of traffic. It

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is also one of the most difficult situations for novice drivers who are not very used to driving [2]. Monitoring left rear involves the motion of turning the body to the left, and at worst, a wheel turn to the left. This may cause a collision with other cars.

In this study we propose a support framework for novice drivers who are not very used to driving cars in safely merging into left main lanes.

2 Related Research

Some studies are related to this theme, including a system of noting the presence of another car passing in order to merge into the main lane via the use of a vehicle detector and DSRC beacons (Fig 1) [3]. Another study provides the degree of danger being displayed on an in-car monitor via the use of a CCD camera attached to the right side of the car and image processing technology [4].

The abovementioned systems are based on software, and both the cost and the time involved can be reduced than using hardware based solutions and can be expected to be put to practical use. However, those systems support cars in the main lane, and do not support cars in a merging lane, many of which involve the premise of cars merging from the left lane into the right main lane.

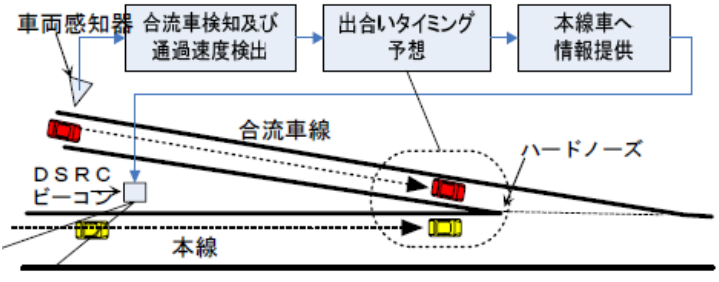


Fig. 1. Basic Framework of Related Studies

3 Outline of Proposed System

(1) External specification of this system. An outline of the equipment setup under consideration is provided in Fig. 2.

With this system a car length and speed sensor is positioned in the main lanes of a high-way and a DSRC beacon in the merging lane. Data measured by the car length and speed sensor is transmitted to the DSRC beacon before being then transmitted to an onboard unit from the DSRC beacon.

(2) Inner specification of the system. This system takes into consideration the data transmitted by the DSRC beacon (the length and speed of other moving cars in the main lane) to an onboard unit that has the data of the length and speed of a merging car itself. The system then suggests whether it is safe to merge or not.

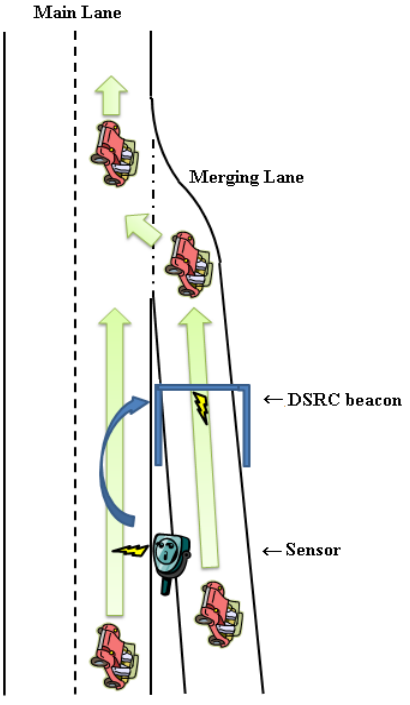


Fig. 2. Outline of equipment used in this study

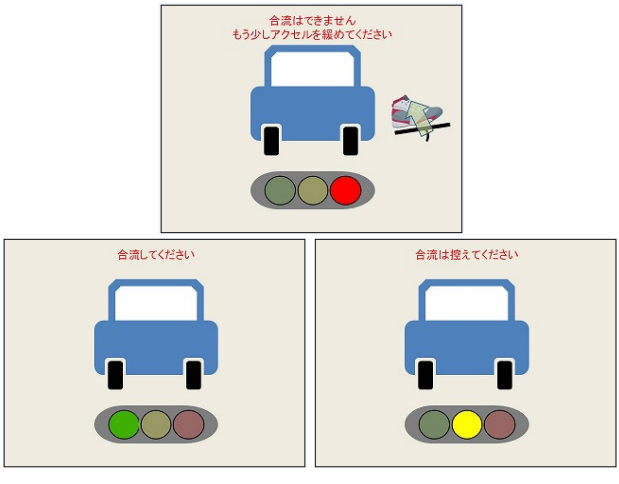


Fig. 3. List of Graphics Presented

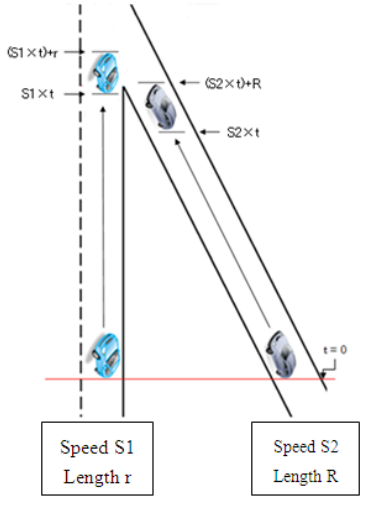
The judgment of merging is shown on the onboard display (Fig. 3). When a merging car approaches a merging area, the onboard unit receives data on the car also approaching to the merging point of the main lane from the DSRC beacon. At this time, the on board system simulates in real-time whether merging is safe using the data from the DSRC beacon and the merging car itself. The system then judges the optimal timing of when to merge and makes the final judgment for the driver. If merging is possible at the current speed, the system displays a green signal. If speed-up or speed-down is required to merge, the system displays a red signal along with a n icon of the gas pedal (speed-up) or the brake pedal (speed-down). During speed-up or speed-down, a yellow signal is on, which urges the driver to pay attention. This support can be expected to make merging easier for beginner drivers.

This judgment is made based on the real-time simulation (Fig. 4).

When a main lane car and a merging lane car are running parallel and the two cars pass the sensor (time t=0), the onboard unit then starts to calculate the travel distance of each car. If a position of the tail of the main lane car compared to the head of the merging lane car reveals no overlap, the system judges merging to be possible.

If there is another car following the main lane car, the system calculates the space between two cars in which the driver can use to merge in safe. Here the main lane car and its follower are supposed to run at the same speed. This is because, if the follower runs faster than the former, the follower will change a lane and pass it, and else if the follower runs slower, the space will widen and merging will become easier.

In addition, the system considers 20m as the safe margin for two cars to merge. This is because it is said that drivers need 0.3 seconds to make a judgment and then to act upon it takes 0.2~0.3 seconds [5], a total of 0.6 seconds. If a car moving at 100km/h, it moves about 17m every 0.6 seconds, and thus 20m is considered to be a safe margin.



$$l_{t+\Delta t} = l_t + S_1 \times \Delta t$$

$$L_{t+\Delta t} = L_t + S_2 \times \Delta t$$

$$l_{t+\Delta t} > L_{t+\Delta t} + R$$

Fig. 4. Information Involved in Real-Time Simulation

Next, suppose that there is a car following the main lane car. In this case, the system reacts differently according to the situation of whether there is a sufficient space for the car to merge or not.

(i) Sufficient space between main lane car and its follower

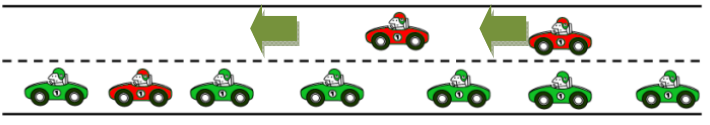


Fig. 5. Merging into enough space between two cars

In this case, the system urges the driver to merge into the space between two cars. The system first displays a red signal to alert the driver and gives a guidance of the speed. When the car adjusts the speed to be in the position where it can merge, the system changes a signal to green.

(ii) Insufficient space between main lane car and its follower

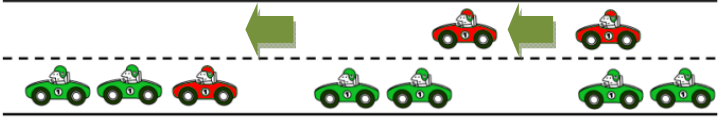


Fig. 6. Merging into insufficient space between two cars

In this case, the system suggests the car slow down so as to merge after the two cars. First the system urges the driver to slow the car down so as to be behind the two cars and displays a red signal before changing it to green.

4 Evaluation Experiment

The system is installed in a car and experimented with it on campus at Ritsumeikan University. The experiments reproduced the virtual merging area (Fig.7). The participants were 10 male students, half of which were novice drivers and the rest drive frequently. The subjective evaluation was gathered by using questionnaires after the drive with the experimental car.

The system was considered effective by all the participants.

Two major opinions were expressed as below.

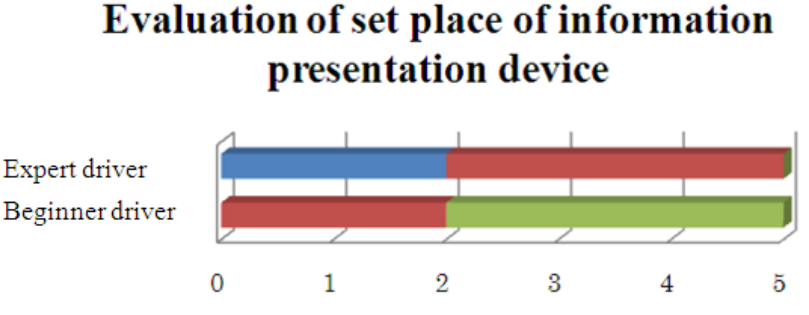
- This system helped alleviate uneasiness when merging
- The graphics are simple and hence we didn't have to scan too much picture content.

Fig. 7. Experimental scene

The defects to be improved were given as below.

- If the system had a sound function it would be more sensory.
- It would be easy for the driver to understand if the tempo of sound changed when approaching to a main lane car.
- Support should be provided not only for merging cars but also main lane cars.

The above opinions were gleaned from the questionnaire.



	Beginner driver	Expert driver
Left	0	2
Center	2	3
Right	3	0

Fig. 8. Evaluation of where the information presentation device should be positioned

A small monitor was used as the information presentation device in the experiment. The participants were questioned on where it would be best positioned so as to be an obstruction while driving. The results are provided in Fig. 8.

The results indicated that novice drivers preferred the right, whereas non-novice drivers preferred the left (in the center).

This is presumably because novice drivers are typically more uneasy with monitoring left rear than non-novice drivers. Novice drivers avoid changing positions, while instead depending on the system and preferring to have the system close to them.

Conversely, non-novice drivers can merge into main lanes without even using the system, and therefore consider it to be one of the aids. They thus think on the left (in the center) to be the best because they can easily check the left side using the rearview.

5 Future Works

We are planning a driving support system that utilizes the road-to-vehicle equipment and CCD-camera. The system uses CCD-cameras instead of DSRC beacons. An outline of the considered set up of the new equipment is provided in Fig. 9. This is because CCD-cameras are more popular in Japanese highways than DSRC beacons.

The current system still has a number of problems. For example, a change in velocity of the main lane cars is yet to be dealt with. CCD-cameras can be used to detect the position and velocity of a car in combination with image processing. This is another reason why CCD-cameras are to be selected in the next step. After performing the image processing the device will transmit the results to onboard units, which will then depict picture content as driving support.

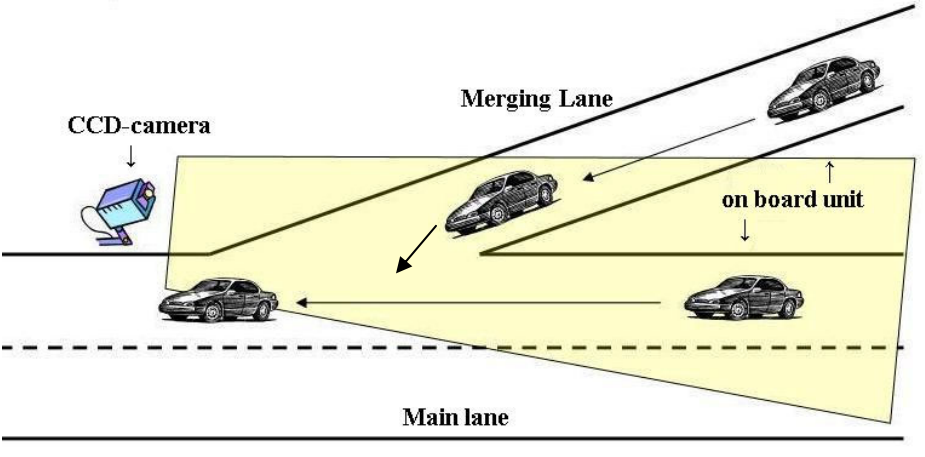


Fig. 9. CCD-camera based traffic detection

In addition, we have to invent an information presentation device, while also reducing the change in center of gravity due to the movement of people's bodies; which is a unique problem with merging into left main lanes from right lanes. With that particular case the driver finds using the rearview to see behind left difficult, and drivers tend to turn the steering wheel using the change in their center of gravity from their body moving. More specifically, we are considering use of a Head-Up Display that makes checking picture content easy when driving a car.

References

[1] Kousoku douro no hashirikata. JAF Mate, 21–25 (2007/8.9) (in Japanese)
[2] Yoshida, Y.: Ease and Safe! Simple Driving Technique, Nihon Bungensya Tokyo (2006) (in Japanese)
[3] Hirai, S., Hatanaka, H., Hirasawa, T., Aya, T., Nishii, S., Nagano, K.: Development of AHS Safe Merging Support Service. In: 6th HIS Symposium, Japan, pp. 331–336 (2007) (in Japanese)
[4] Morita, K., et al.: Merging Support by Image Processing in the Merging Area to Highways. In: 65th Information Processing Society of Japan, pp. 227–228 (2003) (in Japanese)
[5] Matsunaga, K.: Human Science for Traffic Accident Prevention, Nakanishiya Shuppan, Tokyo (2002) (in Japanese)
[6] Japan Safe Driving Center: Research on Night-Time Driving Behavior of Large-Sized Cargo Trucks in the Highways (1999) (in Japanese)
[7] Masakatsu, H., Bagarinao, E., Kurita, T.: Development of Road-to-Vehicle Image Processing Sensor. SEI Technical Review 176, 57–62 (2010) (in Japanese)
[8] Charissis, V., Papanastasiou, S., Vlachos, G.: Interface Development for Early Notification Warning System. In: HCII 2009. LNCS, vol. 5613, pp. 683–692. Springer, Heidelberg (2009)