

TRAFFIC ACCIDENTS IN RURAL AREA AND ASSISTANCE SYSTEM FOR TRAFFIC SAFETY

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Paper Number 186

ABSTRACT

An investigation based on human visual search functions was conducted into the causative factors of traffic accidents at clear intersections in rural areas. The results indicated that it is difficult for drivers to detect a vehicle traveling on a collision course because the vehicle remains in the same position in the driver's visual field. Two systems are introduced to assist drivers' visual searches. One system uses an image processing technique, and the other utilizes DGPS and IVC techniques. This paper presents the development of the assistance system.

INTRODUCTION

There are many rice fields along rivers in Japan that are left over from a previous time. These rice fields are presently being reconstructed into rectangular fields to facilitate the use of agricultural machines, consequently creating wide and straight roads that cross at right angles with good visibility. Although these restructured fields seem to result in safe traffic conditions, many fatal accidents, a small percent of all fatal accidents, occur at intersections with good visibility in these rice fields (1). In this report, an investigation based on the human visual search function is conducted into the causative factors of traffic accidents that arise at intersections with good visibility. We demonstrate that it is difficult for drivers to detect a vehicle traveling on a collision course because the vehicle remains in the same position in the driver's visual field. This paper also presents two systems to assist the human visual search function. One is a system that uses an image processing technique, and the other utilizes DGPS (differential global positioning system) and IVC (inter-vehicle communication) techniques.

This paper is organized as follows. Section 2 provides an outline of traffic accidents at intersections with good visibility in rural areas. In Section 3, the causative factors of these accidents are examined using indoor experiments on the human peripheral visual function. Sections 4 and 5 offer descriptions of two assistance systems using an image processing

technique and DGPS and IVC techniques. The last section is devoted to our conclusions.

ACCIDENTS AT INTERSECTION WITH GOOD VISIBILITY

According to an investigation of traffic accidents in Ibaraki prefecture ¹⁾, located about 100km northeast of Tokyo, over 300 intersections with good visibility revealed evidence of traffic accidents that occurred in the last one or two years.

Other detailed investigations concerning intersection accidents were carried out in eight prefectures ²⁾ (Japan consists of 47 prefectures). The results of the investigations are summarized as follows:

- 1) One hundred and eleven fatal accidents occurred at intersections with good visibility in the year 1995.
- 2) Ninety-one of the above 111 fatal accidents occurred in the daytime.
- 3) Elderly drivers were involved in about 50 percent of the 111 fatal accidents.
- 4) Sixty fatal accidents were caused by drivers not stopping at intersections that required a stop.
- 5) About 65 percent of all fatal accidents were caused by drivers who lived in the cities, towns, or villages where the intersections were located.

Interviews with the persons involved in this type of accident indicate that, strangely enough, they were not aware of the approaching vehicles until just before the collision.

CAUSATIVE FACTOR OF THE ACCIDENT

The above section suggests that although there are no visual obstacles around an intersection, drivers may not be aware of another vehicle on a collision course.

A recent experiment ³⁾ demonstrated that detection of a vehicle on a collision course is difficult compared to detection of a vehicle not on a collision course. In this section, we review this experiment and summarize the results.

Configurations of Approaching Vehicle in the Visual Field

Suppose that two vehicles are approaching the same intersection at constant speeds, but not necessarily at the same speed. We can easily see that there are three possible outcomes.

The first outcome is that, as shown in Fig. 1, one vehicle (vehicle B in Fig.1) passes the intersection earlier than the other (vehicle A). In this case, vehicle B moves from the outer position to the inner position in the visual field of the driver in vehicle A.

The second outcome is the opposite of the first in that vehicle B passes the intersection later than vehicle A. In this case, vehicle B moves from the inner position to the outer position in the visual field of the driver in vehicle A.

The two vehicles A and B do not collide in the above two cases. When one vehicle moves into the visual field of the driver of the other vehicle, they will not collide.

The third outcome is the collision case, as shown in Fig. 2. In this configuration, the two vehicles arrive at the intersection at the same time. It is clear that one

vehicle stays at the same position in the other driver's visual field in this case.

A simple geometrical consideration yields the following conclusions. In collision cases, the slower vehicle A is compared to vehicle B, the farther to the outside vehicle B stays in the visual field of the driver of vehicle A. For example, when vehicle A travels at a speed of 30 km/h and vehicle B travels at 52km/h, vehicle B stays at a position 60° from the front in the visual field of driver A.

We can summarize the above considerations as follows:

- 1) A vehicle approaching an intersection on a non-collision course moves in the other driver's visual field.
- 2) A vehicle approaching on a collision course remains in the same position in the other driver's visual field.
- 3) In collision situations, the faster vehicle appears at the edge of the other driver's peripheral visual field.

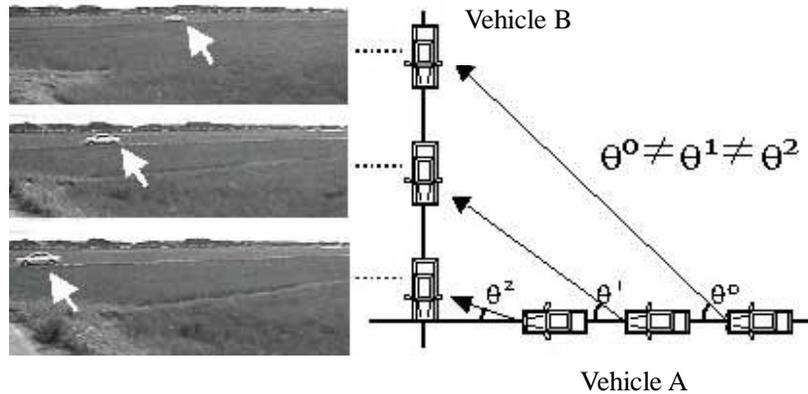


Fig. 1 Configuration of Two Vehicles in Non-Collision Situation

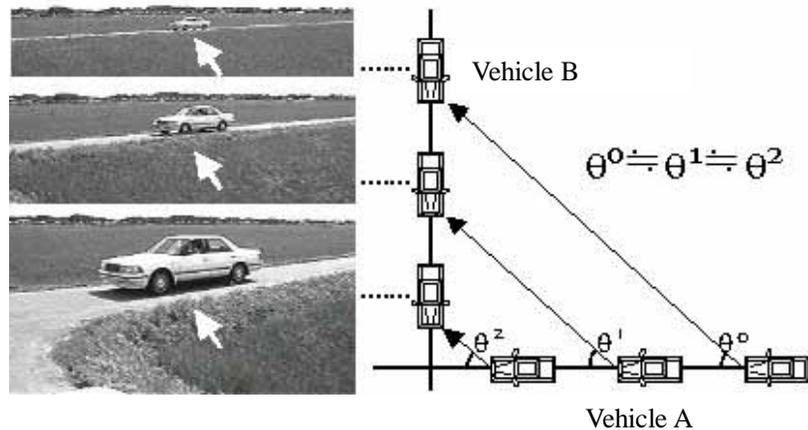


Fig. 2 Configuration of Two Vehicles in Collision Situation

Experiment

We compared the detectability of colliding and non-colliding vehicles by means of indoor experiments. The experiments were conducted using three video clips of traffic scenes at an intersection with good visibility. The three conditions of the video clips were a collision course, a non-collision course, and control conditions. Detailed descriptions of these clips are provided in reference 3.

These clips were presented on displays placed in three eccentric positions, 30° , 45° , and 60° . Three types of video clips were presented three times at random at each of the three positions. The eleven subjects, ranging from 20 to 50 years of age, were instructed to press a button as soon as they detected a vehicle presented on the display by peripheral vision.

Result

Our results are presented in Fig. 3, which shows the angular size of the presented vehicle when it was detected. It is clear that the visual angles in the collision condition are larger than those in the non-collision condition, and this tendency becomes remarkable as the eccentricity is increased.

These angular sizes were translated into a real situation, which is shown in Fig. 4. In this figure, three lines represent the variations in the visual size of vehicles approaching the intersection. The data obtained from the experiments were plotted along three calculated lines. The figure shows that the vehicles on a collision course are difficult to distinguish and can only be detected when they come very close to the intersection; for example, we could detect vehicles only after they arrived at a position 10 m from the

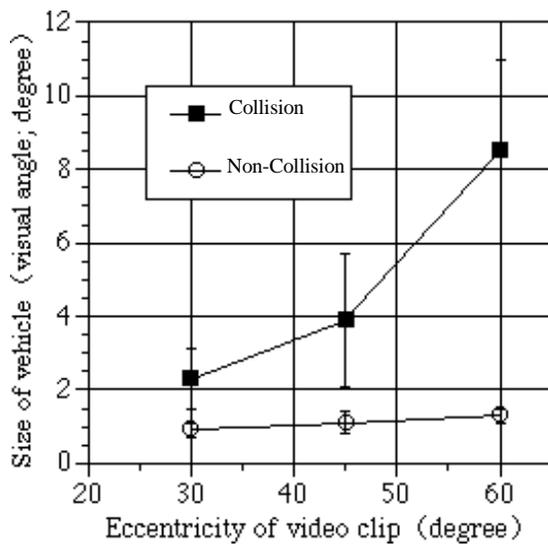


Fig. 3 Mean Detectable Size of Crossing Vehicle

intersection at the eccentric position of 60° .

It is well known that human peripheral vision has poor acuity but is sensitive to motion⁴. It is natural to presume that a driver can detect another approaching vehicle because of its movement. This is true for the case of a non-collision course. However, when two vehicles approach on a collision course, they have difficulty perceiving each other, because they stay at fixed position in visual fields.

Accidents at intersections with good visibility are undoubtedly closely related to a fundamental characteristics of human peripheral vision.

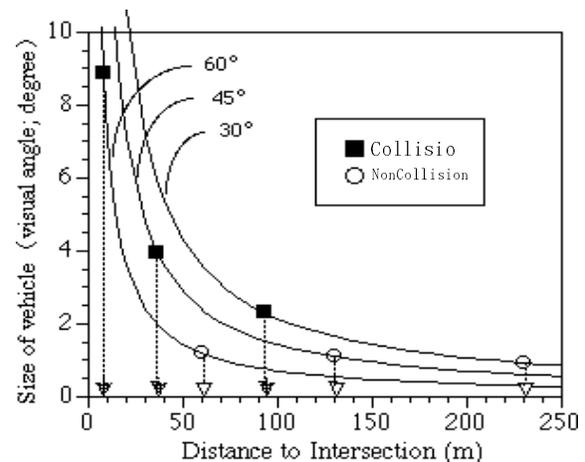


Fig. 4 Translation of Detectable Size into Real Traffic Situation

SUPPORT SYSTEM USING AN IMAGE PROCESSING TECHNIQUE

The above section revealed that human peripheral vision has a weakness that arises in a certain traffic situations and causes accidents. The same weakness may appear when we mimic the human visual information process to construct a support system for drivers using image processing techniques. Therefore, we must use a method that does not mimic human visual processing⁵.

Our system is constructed to compensate for the weakness in human visual processing. More specifically, pictures that correspond to the driver's peripheral visual field are taken with a CCD camera, and two successive pictures are then compared to identify any object that remains at the same position in the visual field, which is the colliding vehicle. An outline of the system is provided in Fig. 5. The system consists of three components: a digital video camera, a video capture card, and a personal computer.

An ordinary binary technique is used to identify an oncoming vehicle. This simple technique is applicable when the contrast between the vehicle and

the background is strong. Another technique, one that analyzes a histogram, must be introduced to cope with weak contrast situations. A combination of histogram analysis and binary techniques can be used to identify oncoming vehicles in weak contrast situations. We must compensate for the sway of the picture resulting from vehicle pitching in order to obtain reliable warnings. A one-point trace technique is utilized to compensate for the sway of the pictures. This method is explained as follows.

First, one static point of the background, for example the top of a mountain, is traced during the image processing to provide a basis for the picture. However much the pictures sway, they can be rearranged using the base point.

The three techniques described above provide reliable warnings in various background conditions. An example of the test run of this system is shown in Fig. 6, which indicates that the system worked well and gave appropriate warnings.

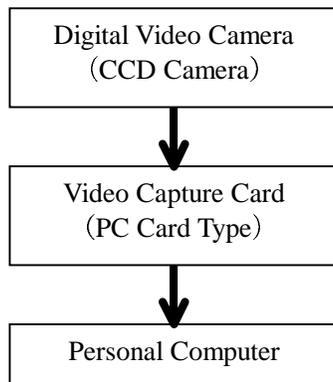


Fig. 5 Components of Assistance System

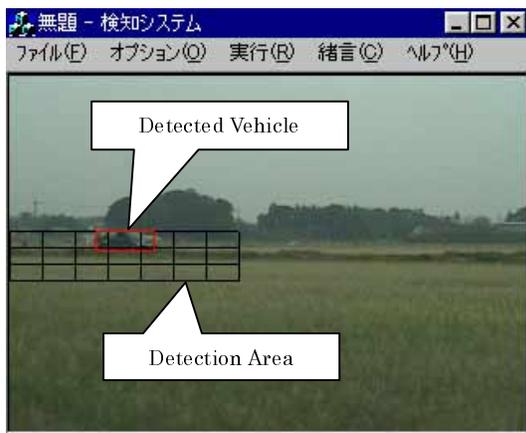


Fig. 6 Example of Test Running

SUPPORT SYSTEM WITH DGPS AND IVC

Another proposed type of system (6) utilizes a differential global positioning system (DGPS) and an inter-vehicle communication (IVC), as shown in Fig. 7.

The system consists of a base station and two vehicles with GPS. The vehicles and the base station receive signals from GPS satellites. The information, which improves the accuracy of the two vehicles' positions, is processed at the base station and is sent to the two vehicles at the same time. Information regarding one vehicle is then transmitted to the other vehicle using IVC. The positions of the two vehicles are stored in the computer, and the relative positions and directions of the two vehicles are calculated in real time. The potential for a collision can be predicted based on this information.

An example of the simulation is shown in Fig. 8. Before simulating our system, two vehicles equipped with GPS and IVC were driven on a rural road near the base station and the information (positions and velocities) was sent to each by IVC; the time series of vehicle information was stored in the on-board computers. The algorithm for this system is simulated with the time series of vehicle information. Figure 8 shows the case of a collision and demonstrates that this system can predict a collision and provide a warning six seconds before the collision.

Although the system has not been completely constructed, its effectiveness was confirmed by experiments and simulations. This system using DGPS and IVC can be a powerful support system in the near future.

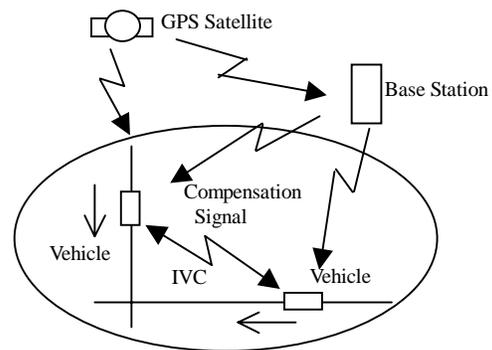


Fig. 7 Basic Components of System

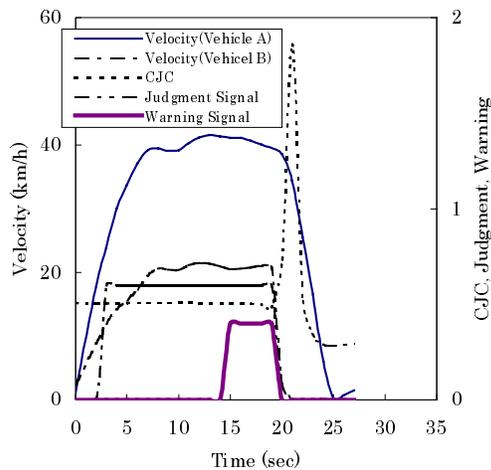


Fig. 8. Example of Simulation (Collision Situation)

CONCLUSION

For this report, we investigated the human visual search function to determine causative factors of traffic accidents that occur at intersections with good visibility .

This research revealed that it is difficult for drivers to detect a vehicle traveling on a collision course because the vehicle remains in the same position in the driver's visual field. Two systems to assist the human visual search function were proposed and

described. One is a system that uses an image processing technique. A prototype of this system was constructed and work well in experiments with actual vehicles.

The other system utilizes DGPS and IVC techniques. Although this system has not been completed, it will be a useful support system for traffic safety in the near future.

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