Study of Traffic Accident Mechanism by Automatic Recording System(TAAMS)

Applications of TAAMS for signalized Intersections and Visualization of TAAMS Images by 3DCG Technique-

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ABSTRACT

Automatic recording system (TAAMS) was improved for signalized intersections, which has additional devices for detecting and display the states of signals when an accident occurs as main functions. Video pictures (40 or 80 flames) including just before and after accident or near miss phenomena can be recorded by the TAAMS. The TAAMS were installed on the six intersections with and without signalized intersections with different sizes, and field trails were carried out for 30 months from 1994. The TAAMSs have been worked without interference with the continuous operation of the traffic signals. Approximately 150 accident cases and a lot of number of near miss phenomena were recorded. The data were analyzed to assess the implications for driver behavior. In accident investigations particularly at signalized intersections, the images of TAAMS were employed to elucidate implications in state of signals and the driver behaviour. The results are concluded that the TAAMS data helpful for investigators because of providing some fundamental information such as locations of vehicles relations to the state of signals at the accident, their velocities, a collision point, etc.. In addition, applications of 3 dimensional computer graphic technique (3DCG) will be also discussed for study of accident mechanism using TAAMS image data in this paper. When and/or under what specific situations drivers in pre-accident stage had misjudged are discussed with driver view fields through the animation generated by 3DCG technique.

1. INTRODUCTION

A key to the solution of traffic accident mechanisms at intersections with signals is its relation with states of signal before and after accidents. However, reliable information cannot always be collected because many people involved with accidents do not clearly remember the color of the signal shortly before the accident and are afraid of being condemned for the fault of the accident itself. This paper describes the display function of a state of signal which was added to the Traffic Accident Auto-memory System (TAAMS)[1],[2] as well as results from a field test. This paper also reports the application example of preventing recurrence of similar accidents by improving a road marking at an intersection based on results of video data analysis and reviews the possibility of TAAMS for traffic engineering.

On the other hand, many factors are

associated with traffic accidents, but over 90% of causes is due to human factor according to both UK and USA reports[3]. Particularly, it is common saying that the main cause of cross accidents at intersection is attribute to error of cognition or misjudgment on safety.

In research on decision making of drivers, there have been very few instances in which actual vehicular behavior in accidents has been recorded. In the study of these assumptions, we have analyzed vehicular behavior immediately prior to accidents employing data from TAAMS(3),(4) and studied the contributory factors which have affected the decision making of drivers. TAAMS data is, however, second dimensional image, it is difficult to discuss visually of intersection through driver's views, while the 3DCG technique in computer is convert from the images of two dimensions to of three dimensions. Using 3DCG technique it is easy to produce the images from different views such as drivers' view fields. For example, we can examine through the 3DCG images whether the driver on the minor road can look the vehicle running on the major road from the stop line or not.

2. METHOD

2.1 Outline of TAAMS

Figure 1 illustrates configuration of TAAMS improved for signalized intersections (2 camera type). The cameras and microphones are mounted above the intersection, where the camera field of vision includes the junction approaches (approx. 25m), and the junction itself. The memory unit continuously stores the image and sound collected through camera and microphone from the intersection. The VTR recorder is activated by the sound discriminator. When activated the VTR recorder takes either forty (or 80) pictures at normal speed of 1/10 second. The system then automatically resets for next actuation. It is claimed that one 120-minute videotape can store details of approx. 1,000 (or 800) cases.

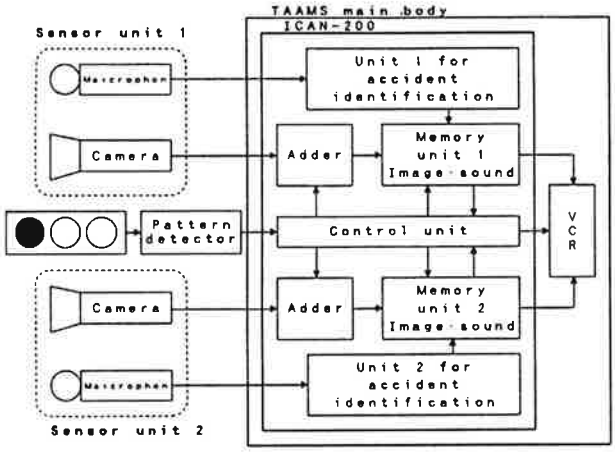


Fig.1 Schematic of TAAMS

2.2 Function of Detecting Signal State

Figure 2 is a configuration diagram for detecting states of signals. A current sensor is attached to the cables of signals in the signal controller and the flow of electricity in each cable is detected without contact. TAAMS converts this detected electricity first to parallel state signals, then to RS-422 signals and distinguishes the combination of lighted signals and adds the name of the step to the video data.

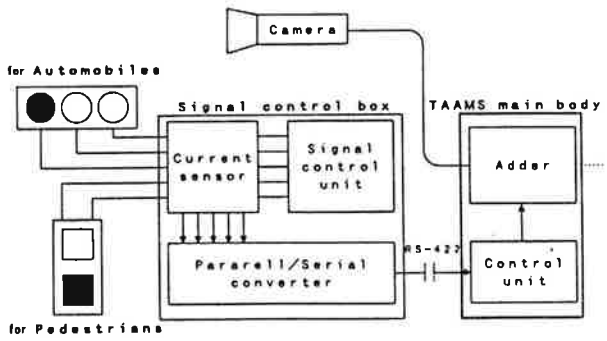


Fig. 2 Schematic functions of detection and display for states of signal.

2.3 Performance Test of TAAMS

Three systems of TAAMS, with additional functions of detecting states of signal, were experimentally installed at three signalized intersections of different scales such as a small, regular and large scale, respectively. The field tests were completed with cooperation of the Metropolitan Police Office. Figures 3 and 4 show a plan of the large scale intersection, and the signal step table used in the intersection, respectively.

Plan of Signalized Intersections

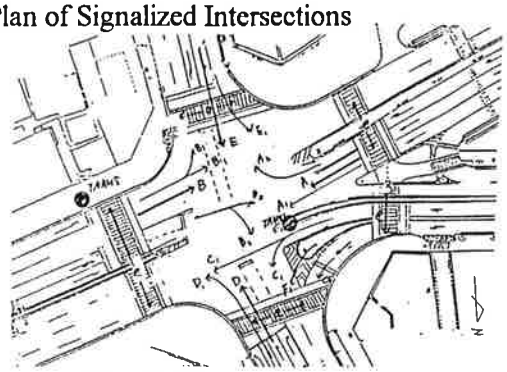


Diagram of Signal Steps

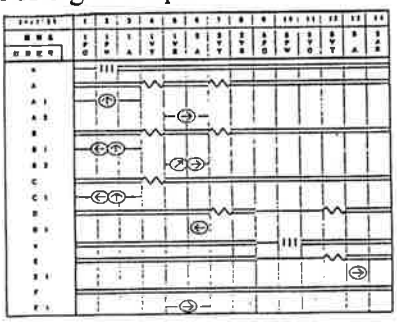


Fig. 3 An Intersection with Traffic Signals.

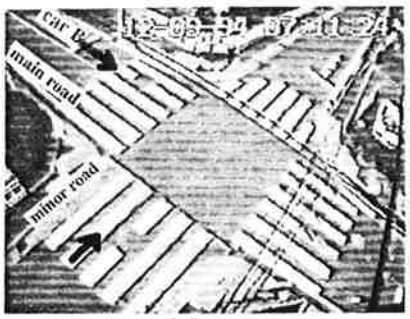
For the field test of automatic recording function on TAAMS, commercial 120-minute videotapes were used and were replaced every one month. An analytic study of the recorded video data was conducted. Performance tests on detecting and display states of signal were also carried out through conducting continuous recordings in the field, with the automatic detection function of video data tentatively turned off, using commercial 210-minute videotapes in a triple-speed recording mode (recorded 10.5 hours/one tape).

2.4 Application of 3DCG Technique

The PRISMS 3D[4] animation system is a totally integrated software package, components: stage, action, ice etc., from which animation can be produced on workstation computer such as Indigo by Silicon Graphics Co.. In the production of 3DCG animation, a hardware, software and video system are used as follows. For hardware Indigo2 Extreme (Silicon Graphics-Cray Co., Ltd.) with CPU R4400, memory 128 Mbytes, Disk 6 GBytes, and for software 3DCG PRISMS (Side Effect Software Co., Ltd.) and PVW2800 (Sony Co., Ltd.) are used mainly, respectively. The basic procedure of 3DCG images and animation generated is as follows.(1) The 3DCG image of the intersection is constructed basis on TAAMS data and geometric data of the site of intersection within the computer. (2)Camera position of TAAMS is calculated by the computer, and the viewpoint of the image is set up at the camera position. (3)Vehicles involved in accident are incorporated in 3DCG image data. And then vehicles are loaded according to the tracks calculated previously, the each original 3DCG image are produced in order.

2.4 Intersection without Traffic Signals

Figure 4 shows one of the unsignalized intersections, which have informal priority rule in Japanese traffic law. One roadway represented is regulated with stop sign and pavement marking with stop line on the pavement. On otherwise, the cross way to the way with stop line might be priority (right-of-way), but all vehicles must yield before entering the intersection. Therefore, the roadway with stop sign has poor priority (informal minor road), and the crossing way on it has rich priority (informal major road).



TAAMS Image

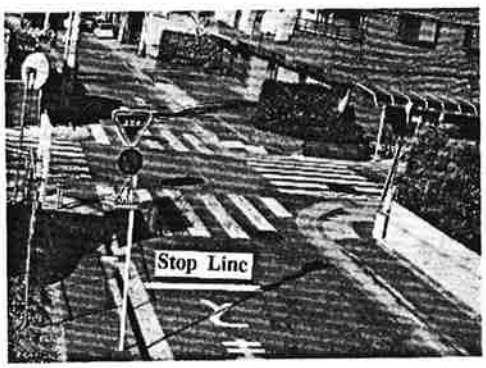


Fig.4 An Intersection without Traffic Signals.

2.5 Intersection Image by 3DCG

Figure 5 illustrates the solid model of the intersection installed TAAMS from different viewpoints constructed by 3DCG technique. The model of the intersection is rendering images at full resolution as similar views of shown in Figure 4, it would be resemble enough detail to the intersection.

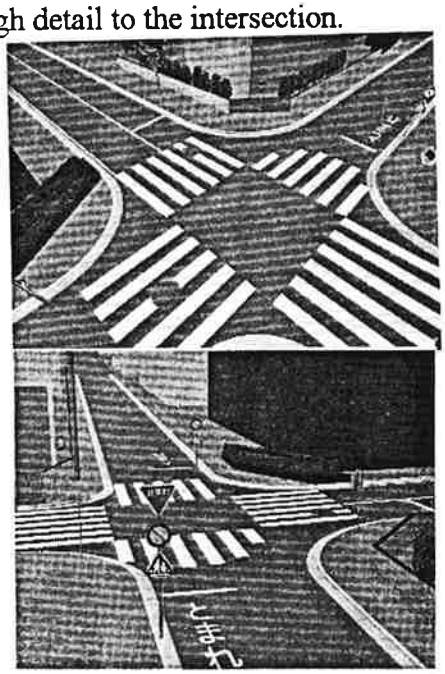


Fig. 5 Solid Image of Intersection constructed by 3DCG technique.

Using the images on computer screen, it is possible to examine the view obstructions through driver's eye views, for example we can investigate whether the driver running major road when he had loaded an emergency brake could see or not the vehicle on the minor road.

3. RESULT

3.1 Results of Tests for Signal States

The function of detection for signal states was determined to have not affected the control of the normal signal function at all. As for accuracy of signal states, analysis of video data recorded by continuous recording mode (with the automatically detecting accidents function tentatively turned off) confirmed that TAAMS completely detected and recorded accurate signal situations.

Figure 6 illustrates an example of traffic flows randomly picked out from continuous recorded video data by TAAMS. It shows that the symbol for signal step in each picture (1) is according to the order specified in the step table and (2) can logically and fully explain the traffic flow at the time according to the situation of states of signal (symbols of signal steps). This Figure 6 demonstrates that signal states were accurately detected and displayed.

3.2 Accident at Signalized Intersection

Figure 7 shows scenes of car crash between a passenger car going straight and a box car turning to left, which occurred at the intersection shown in Figure 3. The signal state (1PG) indicates that the crosswalk in upper right of the picture was at a "green" step. This means "green" for the passenger car going straight and "red" for the car turning to right, so the box car which turned to the right

crossing vehicular behavior at unsignalized intersections.

The driver running on the minor road was induced illusion by vehicular behavior on major road, which was stopped in front of him. At least, it is inferred that his vigilance level at preparing stage would be affected by the vehicular behavior of other oncoming vehicles. In circumstances immediately prior to accidents, the illusory safety judgments of drivers predominate in unsignalized intersections, and are found to be directly related to the causes of accidents.

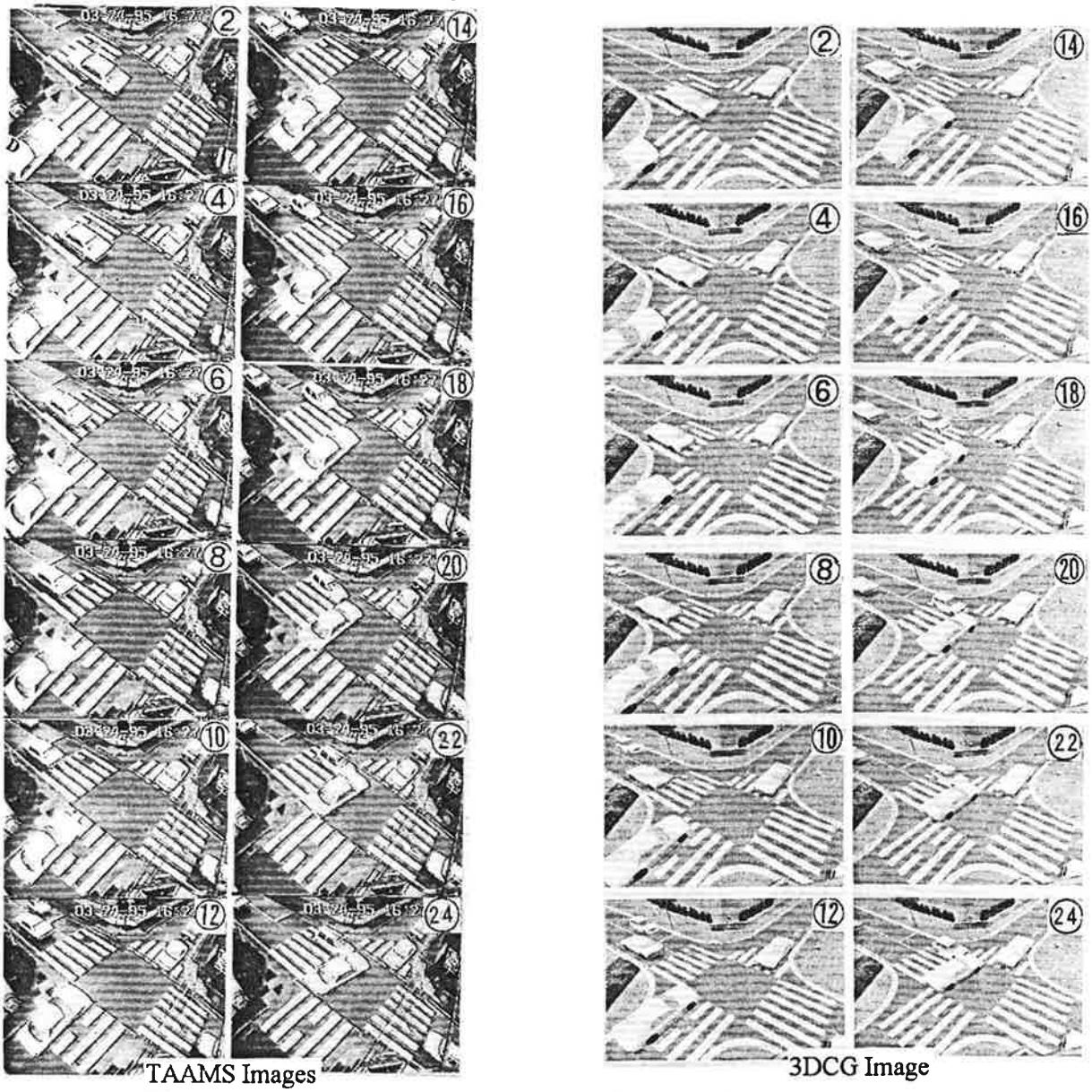


Fig.11 Accident Scenes at Unsignalized Intersection by TAAMS and 3DCG.

Figure 12 shows the results of analysis of the speeds vs. times of vehicles. Vehicle C on the major road passed the intersection at about 20 km/h. Vehicle D was following to vehicle C at low speed. Vehicle A on the minor road to allow vehicle C to pass the intersection first, which was approaching the intersection at an extremely low speed of about 5 km/h. This behaviour indicates that vehicle A either stopped at the Full Stop line or had reduced speed extremely for safety. Furthermore vehicles E and F, on the opposite

side of the thoroughfare, were waiting at the pedestrian crossing and at the Full Stop line for vehicle C to pass through the intersection.

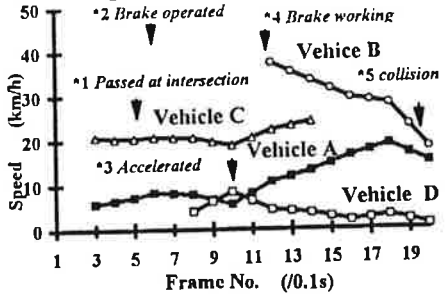


Fig.12 Speed vs. Time.

In other words, driver of vehicle A seem to be a careful driver as same as drivers of vehicle E and F as shown in this manner. However, as shown in Figure 4, driver A increased speed from 5 km/h to 20 km/h to cross the intersection immediately after the vehicle C passing, whereas vehicles E and F stile stopping. At this time, what he had to check was oncoming vehicles on crossing road from both sides of the left and right of him.

Why did driver A make decision to cross the intersection at that time? What did him make decision to do? He have misjudged certainly at preparing stage. It is inferred that he was induced illusion by mainly the vehicular behaviour of vehicle D, and also vehicle C. The behaviour of vehicle D stopping performance affected driver A's judgment on cross particularly, he would understand the situation that driver D gave the way him by stopping action. However, one more important safety checking was remained him, that is, exit of oncoming vehicle from the left on crossing road.

Figures 13 and 14 show the four scenes, which is TAAMS data and 3DCG images, respectively, when the something events observed in the approaching, preparing and crossing stages in Figure 11. Figure 13-A indicates the respective positions of all the vehicles immediately after vehicle C crossed the intersection (Frame 5 in Figure11). Vehicle A was on the pedestrian crossing and was just prior to deciding to cross. On the crossing line, vehicle D to the right of vehicle A appeared on the screen approaching the intersection. However the vehicle "vehicle B" approaching the left side of vehicle A has not yet appeared on this scene as shown in Figure13-A.

Figure 13-B(14-B) illustrates the respective positions of all the vehicles when vehicle A increased his speed to cross the intersection (Frame 9 in Figure11). Vehicle B oncoming toward intersection was on the scene at approx. 13m away from the intersection. And in Figure 13-C(14-C) vehicle B was approx. 10m away, it was loaded brake for avoid a collision with vehicle A. But driver A has increased the speed at that time already. Figure 13-D(14-D) represents the scene when both drivers of vehicle A and B could be seen each other because of vehicle C running away from the intersection. During scenes shown in Figures 13-B and 13-C driver A could not see vehicle B because of obstacle by body of vehicle C.

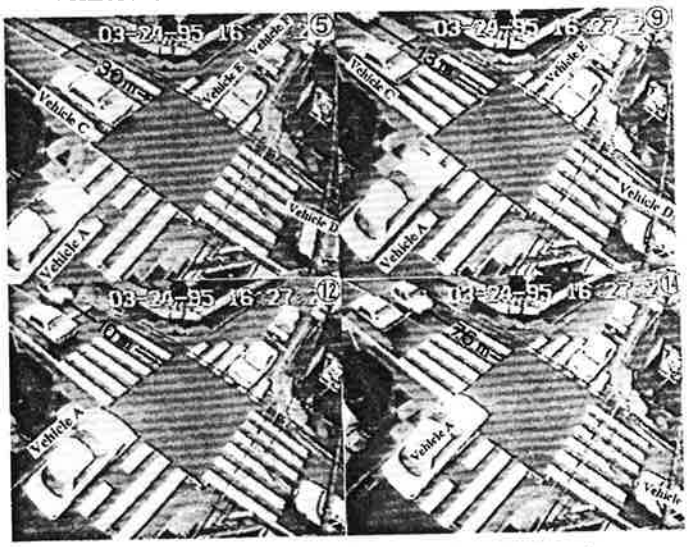


Fig.13 Event Scenes refer to Driver behaviour.

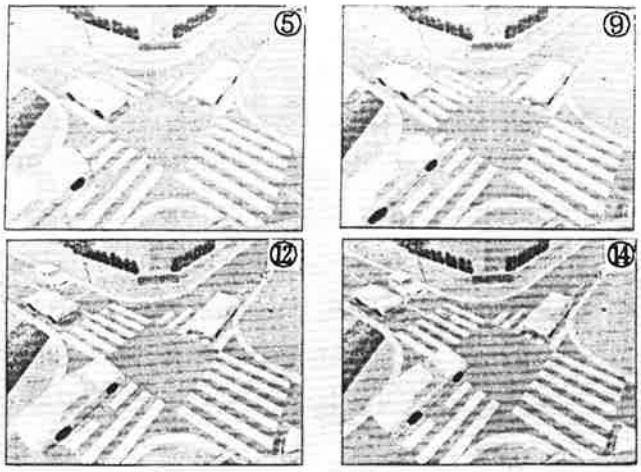


Fig.14 3DCG Image refer to Driver behaviour.

The animation was generated enable the viewers to see the scene in the true perspective from any chosen viewpoints using the original images.

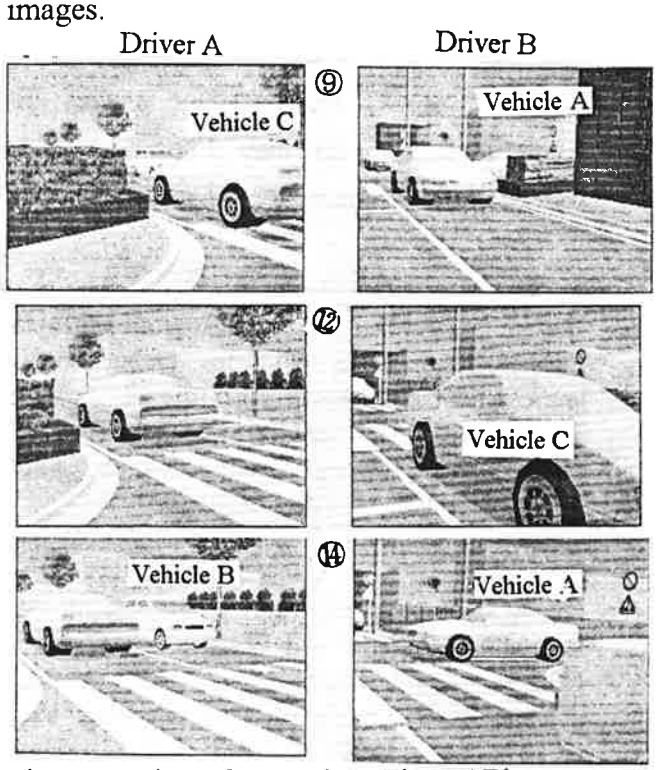


Fig. 15 Views from Driver A's and B's Eyes.
(at Frame No. 9, 12 and 14)

When the animation as three dimensional images is once generated in the computer by 3DCG technique, it is able to relative easy modify according to specific conditions. For example, views from driver A eyes on preparing and crossing stages as shown in Figure15 as models of the visual images for practical tool using the traffic accident mechanism. He could not see vehicle B approaching to the intersection mostly time, except only (as shown in Figure 15-B) an instant, because of obstacles by body of vehicle C. The animation is informative means to instruct why drivers make misjudgment or what make him decision at approaching and/or preparing stage in the intersections.

5. DISCUSSION

5.1 Application for Signalized Intersection

TAAMS data suggest a clear relation between the state of signal just before an accident and the driver's action (horn, emergency brake, etc. for example) by analyzing the video data and traffic sounds that were recorded by TAAMS to effectively study the mechanisms of accidents at intersections with signals. Therefore, new classification methods would be possible, which are different from traditional methods using the results of these traffic accidents, inclusive of classification, by focusing on factors which may cause accidents from the intent of preventing them.

5.2 Application of 3DCG Technique

In this paper, an traffic accident mechanism as a model by TAAMS data and modified image using 3DCG technique is offered and discussed, for examples, as shown in Figure 10 through the driver's eye views are very informative. The images was used to explain and confirm that driver views such as when he decided to cross the intersection. It is concluded that he decided to cross intersection in spit of impossible seeing vehicle B oncoming toward intersection by obstacle of vehicle C passing just before.

In the example, the drivers on the minor

road ware regarded as careful driver, because who decreased approaching speed enough such as around 10 km/h. This fact suggest that they never ignored the crossing vehicles in the approaching stage. In the preparing stage to cross intersection, they only judged the situation was safe. The problem is why they judged the situation safe in spite of oncoming vehicle on cross road.

Why did not he check to the left to look for vehicles oncoming? Probably, he judged the situation was completely safe because vehicle D was stopping in front of him. But what driver D did was only to avoid collision against vehicle A, it doesn't mean to compensate that vehicle A could cross the intersection at that time.

But driver A only paid his attention to cross the intersection. What made him neglected to check safety? At least, this case suggest that the situation changed from unsafety to safety in his mind in a moment. The phenomenon may be attribute with human information-processing rather than that individual characteristic. Therefore, to explore this mechanism may lead to find predictors of accident involvement at the intersection without traffic signals.

As indicated in the example, in considering the influences upon safety judgments, it is not only necessary to clarify the situations which bring about misjudgments but it is even more important to ascertain in detail circumstances resulting in a complete absence of vigilance due to safety factors being indicated immediately prior to that loss. If such situations are frequently generated in traffic streams, their resolution is of the utmost importance in resolving problems of traffic safety.

6. CONCLUSION

The functions of TAAMS for signalized intersections was tested in the field tests, which can detect and display signal states continuously without affecting the control of the normal signal functions. Also, an example of countermeasure is reported, which refer to the road marking for improvement of the signalized intersection.

In addition, an example of decision making of the drivers have been demonstrated through actual example to might been greatly influenced by the vehicular behavior immediately prior to the accidents by TAAMS data and 3DCG images. The images and animation indicate that they are useful tools for studies of the mechanism of accidents.

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REFERENCE

(1) M. Ueyama and M. Koura, "Automatic Recording System and Traffic Accidents at Uncontrolled Intersection by TAAMS". Presented at 15th ESV Conference , Proceeding Vol.2, pp.1476- 1486, 1996.

(2) M.Ueyama, The Study of Traffic Accident mechanism at Intersection by Automatic Receding Systems", Presented at Conference of Road Safety in Europe, Proceeding No.7A, Part 2, pp.95-108, 1996.

(3) K. Rumer, The role of perceptual and cognitive filters in observed behavior. Human Behavior and Traffic Safety, (cite in: L. Evance, Traffic Safety and the Driver, p.92-93,1991).

(4)Side Effects Software Inc., Reference Manual, Vol. I, "PRISMS 6.0", 1995.