VEHICLE TRACKING SYSTEM USING DIGITAL VCR AND ITS APPLICATION TO TRAFFIC CONFLICT ANALYSIS FOR ITS-ASSIST TRAFFIC SAFETY

Hiroshi Wakabayashi
Professor, Faculty of Urban Science, Meijo University, 4-3-3, Nijigaoka, Kani, Gifu 509-0261, Japan
e-mail: wakabaya@urban.meijo-u.ac.jp

Kazumi Renge
Professor, Faculty of Humanities, Tezukayama University, 7-1-1, Tezukayama, Nara, Nara 631-8501, Japan
e-mail: renge@tezukayama-u.ac.jp

ABSTRACT
This paper presents the Vehicle Tracking System using a digital VCR and its application to the conflict analysis at the many accidents occurrence point for developing ITS-assist traffic safety system. The developed system consists of Video Image Capturing Subsystem, Image Processing Subsystem, and Transforming Coordinate-System (from pixel coordinate-system in the perspective image to $x$-$y$ (plane) coordinate-system) Subsystem. First, the outline of the proposed vehicle tracking system is described. Second, its application to the actual traffic conflict analysis using conventional conflict indicators as TTC, PET, and etc. at the intersection traffic flow. Since the vehicle tracking system is very accurate, every location of target vehicle can be identified accurately. Thus the conflict indicators are highly reliable ones. The characteristics of these conflict indicators such as TTC, PET, and others are discussed. Then based on these discussions, the requirements for desired conflict indicators for truly appropriate and effective alert for drivers are discussed for ITS-assist safety system.

EXTENDED ABSTRACT

1 INTRODUCTION

Many collision occurs at frequent viewing occurrence section and merging / diverging sections. To prevent vehicle-to-vehicle accidents at these sections, it is efficient to forecast conflicts accurately and to alert drivers quickly using ITS equipment.
This research aims at developing appropriate and truly effective conflict indicators. When ITS technology enables highway-to-vehicle and vehicle-to-vehicle communication for safety, the basic information for supporting traffic safety such as alerting system is quantifying conflict events and its forecasting. Thus the development of appropriate and effective conflict indicators is quite important.

Older and Spicer (1976) have proposed traffic conflicts classification. It has been a useful classification for traffic conflict analysis. It was, however, subjective classification, and they proposed no objective indicators. Hayward (1972) has proposed TTC indicator. This indicator is Time To Collision, if the two vehicles continue to drive at the same speed and the same angle without any evasion behavior. Allen et al. (1978) have proposed PET indicator. PET is the Post-Encroachment-Time, the time of the vehicle to the place where another vehicle once occupied. It is near-miss indicator. These TTC and PET indicators are objective ones, but difficult to obtain. In those days when digital cameras or computers were not available, they seems to use motion pictures. The analysis procedure seems to have consumed a lot of motion films and the discrimination of traffic conflict should have required a complicate human works. Analyzing the traffic conflict should have needed complicate and heavy human works. The quantification of the conflict and its projective transformation from image to the actual plane coordinate are also presumed to be difficult.

After those days, the analogue VCR era has come. These analyzing systems were methods using pointing device such as digitizer (Koike et al., 1988) or using analyzing paper pasted on the display. There have been some problems, however, that the playback image vibrates since analogue videocassette recorder and analogue monitor are used. Thus the analyzing process requires technical skills and nevertheless the accuracy is not high. Although the method with digital processing was desirable, it was very costly and impractical for academic use (Koike et al., 1988).

As is stated above, although TTC indicator by Hayward and PET indicator by Allen et al. has been proposed so far, there are not so many reports about traffic conflict analysis using those indicators due to its difficulty.

In this study, first, Vehicle Tracking System using a digital VCR is developed. Since this system can identify vehicles’ locations very accurately at arbitrary intervals, it enables highly reliable conflict analysis with quantification.

In these four or five years, however,
1) digital VCR cameras for home use are available,
2) easy-handled language for personal computer has been improved, and;
3) a high resolution video capturing device and its software are provided.
Thus, vehicle tracking system can be economically developed in a small computer system without
combining with other devices complicatedly. The proposed system developed by the authors records target
vehicle’s tracking on the display with mouse pointing device, transforms the tracks on the display into the
actual tracks on the road, and obtains the vehicle’s speed, distance for each time slice, acceleration, and so
on.

2. VEHICLE TRACKING SYSTEM WITH DIGITAL VCR

First, the proposed vehicle tracking system is explained. This system consists of following subsystems:
1) Video Image Capturing Subsystem,
2) Image Processing Subsystem,
3) Transforming Coordinate-System Subsystem.

Visual Basic (Microsoft Visual Basic Professional Edition Version 5.0) is used as the language in
developing this system. The video image is processed into numerical data as the following procedures:

2.1 Examples of the played back image and the characteristics of this method

Figure 1 demonstrates the played back image using the Vehicle Tracking System using Digital VCR, and
Fig.2 illustrates the records of a vehicle track.

The advantages of the proposed system are as follows:
1) The use of digital camera, digital processing and digital monitoring reduces vibration greatly.
2) Position data of the moving object can be recorded very accurately with perfect stillness, without any
vibration of both monitor and video recorder.
3) Input error depending on an analyzing individual can be reduced with the above (2)) characteristics and
slow speed playback.
4) A lot of data of the positions can be recorded in a short period.
5) Successive data processing is available in the same PC. This enables the successive statistical analysis following the calculation, e.g., vehicles’ speeds and accelerations, with ease.

Most important feature of this system is digital data processing. In an analogue system, both analogue video recorder and analog monitor cause the vibration of the image, and thus the obtained position data were unstable. In the proposed system, any vibration never occurs using digital video recorder and digital monitor.

3. APPLICATION OF THE VEHICLE TRACKING SYSTEM TO TRAFFIC CONFLICT ANALYSIS

Photo 1 is one of scenes of the very dangerous traffic conflicts from actually recorded digital tape. For this conflict, the proposed system is applied and plotting every vehicles’ location at 0.2 seconds interval leads to the result shown in Fig.3. This result demonstrates the accuracy of the proposed tracking system.
Next, several conflict indicators are proposed, adding to the TTC by Hayward and PET by Allen et al.

1. TTC indicator
   TTC is defined as the Time To Collision, if the two vehicle continue to run at the same speed and angle without any evasion behavior. The maximum value is infinite and the minimum is zero, i.e. collision.

2. Approximate TTC indicator
   This indicator is proposed by the authors. Hayward’s TTC indicator has the following demerits that the indicator is calculated infinite (i.e. two vehicles run very safely) although the two vehicles run in a very seriously dangerous position.
   i) Even when the time difference of two vehicles is very small, e.g. 0.1 seconds near miss closeness and the collision is avoided, the TTC indicator is calculated infinite. This has no reality.
   ii) If two vehicles run very closely side by side and almost in contact, and if the relative angle is zero or very small, the TTC indicator is calculated infinite or very large. Large value of the TTC indicator indicates these two vehicle locate very safely. This is also meaningless.

To compensating for these defects, the approximate TTC indicator is proposed.
(3) PET indicator
PET indicator has been proposed by Allen et al. (1978) as the Post-Encroachment-Time. PET is defined as the time that the vehicle-2 arrives at the potential collision point where vehicle-1 currently occupies. This is the time difference between two vehicles those occupy the same point. Thus this indicator demonstrates near-miss indicator.

(4) Distance for cross-sectional direction.
(5) Distance for longitudinal direction.
(6) Euclid distance.
The results of the conflict indicators for the seriously dangerous conflict in Photo 1 are shown in Fig. 4 and 5. In this case, TTC, PET and other indicators are calculated to be very seriously dangerous situation of the two vehicle because these value are less than 0.5 or 1.0 seconds that is the time of human reaction. This is also understood from the situations of the two vehicle in Fig.3 and Fig.5.

![Fig.4 Longitudinal Change in Conflict Indicators(1)](image)

![Fig.5 Longitudinal Change in Conflict Indicators(2)](image)

4. DISCUSSION AND CONCLUSION

(1) In this case, almost all conflict indicators have significant values worth alerting for driver. As stated
above in TTC indicator, however, there is a case that indicator indicates safe traffic condition although the traffic condition is seriously dangerous. In such cases, there are still future subject to develop the appropriate conflict indicators.

(2) When the traffic condition is slightly congested and every vehicle runs closely each other, indicators are calculated to indicate dangerous traffic condition. In such case, ITS-assist system always alerts. Thus this is inappropriate for supporting safety driving because the system does not notify when the truly dangerous condition occurs. If the criteria of the conflict indicators for alerting are strictly operated, the alerting is not provided even when the truly dangerous condition occurs. Thus, we should accumulate more cases and analyzing, and should develop appropriate and truly effective conflict indicators.

REFERENCES


