REVIEW ARTICLE

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SEYYED MOHAMMAD SADAT HOSEINI*

Using a police warning system to eliminate errors in intelligent violation detection systems

Abstract

A broad range of diverse technologies under the generic topic of intelligent transportation systems holds the answer to many transportation problems. Tailgating and the failure to maintain sufficient distance from the next vehicle are among the biggest causes of motorway accidents. There are intelligent systems to detect this violation. Their insufficient accuracy is, however, the reason they are used with reluctance. In this research, a police warning system is proposed to note the detected violating drivers by a short message service. If the violation is repeated, the driver will be fined. Using probability logic, it has been shown that by the proposed system, we can be sure that the error in traffic ticketing will be very low. A survey of police officers found that most of them welcome the proposed system.

Keywords: *police warning system, intelligent transportation systems, errors, violating driver.*

1. INTRODUCTION

Traffic accidents constitute one of the leading causes of death in many countries. Despite the current efforts devoted to mitigating the effects of road incidents, some variables still affect this problem that is not yet under control or regulation. In many cases, the rationale is that these behaviours are hard or expensive to detect reliably, thus limiting the extent of the automatic detection systems (González, 2016, p. 3).

Among the violations that are not fined despite their importance and the existence of their detection system due to the lack of accuracy, one can mention the violation of safe

* Assistant Professor, Traffic Police Department, Amin Police University, Tehran, IranSadathoseini1@yahoo.com

distance and crossing the continuous line (Naranjo et al., 2003, pp. 132-142). According to Iranian traffic regulations, a safe headway must be at least 2 seconds. Namely, a study of traffic counter statistics on Iranian roads shows that at each section of the road, about 3 to 4 per cent of drivers do not observe the safe distance. (Road Maintenance and Transportation Organization, 2021) These drivers are the cause of many traffic accidents.

In this paper, a solution for using inaccurate ITS systems is proposed. A certain number of warnings are given to a violating driver, and if the warnings are not heeded, and the violation is repeated, the driver will be fined. In this way, one can be sure that the fined driver must have committed the offence at least once. This research provides the answer on how to reduce the effect of law enforcement equipment errors by using a warning system. This paper introduces some existing systems for penalizing drivers who did not observe a safe distance. The results of some research on the effect of vehicle fines on road safety are also explained. Then, the police warning system is proposed, and the survey results regarding the level of police officer acceptance of this system are presented.

2. LITERATURE REVIEW

Tailgating and the failure to maintain sufficient distance from the next vehicle are one of the biggest causes of motorway accidents (Vogel, 2006, p. 427). CatchSystems working with its German sister company, Vidit-Systems, has developed the Video Control System to easily and automatically detect and register these violations. The VCS system can also detect and register violations of the speed limit. With its VCS system, Vidit-Systems is the market leader in Europe when it comes to detecting violations involving tailgating and excessive speeds with the help of video registration technology. The certified video images provided by the system can also detect and register violations involving a failure to use safety belts, the use of mobile telephones, and passing other vehicles in a no-passing zone (catchSystems, 2021).

Tailgating is difficult to detect and document by using visual methods, and law enforcement agencies must depend on trained officers whose abilities may be limited. Zelmer et al. (2014) proposed a tailgating detection system mounted to the officer's patrol vehicle that continuously monitors both passenger and commercial vehicles as the officer travels down the roadway. A rotating laser range-finding sensor feeds information to a microprocessor that constantly searches for the occurrence of tailgating. A weighting algorithm determines when a tailgating event has definitively occurred to reduce system sensitivity. The officer is notified with audio and visual cues if an event is detected. A time-stamped record including all relevant system information for later use in legal prosecution is also produced (p. V002T30A001). This system has had good results in simulation conditions but has not been tested in real conditions.

Hosseini et al. (2009) used image-processing techniques to develop an online system that calculates the longitudinal distances between vehicles. Their proposed system facilitates controlling the safe distances between vehicles without needing high-technology devices. Their real-time approach uses simple but efficient operations to reduce the computation time

(pp. 303-310). Hoseini proposed the system made many mistakes in detecting offending vehicles, which, in practice, were not accepted by traffic police agencies.

Zhijun et al. (2017) proposed a solution for dangerous driving behaviour detection using video surveillance systems. Dangerous driving behaviour such as Abrupt Double Lane Changes, Retrograde Driving, and Illegal U-Turns are considered. Their study aimed to develop a detection method of dangerous driving behaviour based on video surveillance. They used trajectory histograms of vehicles to detect Dangerous driving behaviour. A set of trajectory histograms is constructed to represent vehicle motion (pp. 409-421). This study helped investigate drivers' behaviour but has not been used to enforce offending drivers.

Moshiri & Montufar (2017) evaluate the stop-bar detection and count the performance of three advanced vehicle detection sensors under various environmental conditions at a signalized intersection. Continuing advancements to vehicle detection technologies and improvements to their detection capabilities to overcome issues from impacting conditions necessitate testing the performance of new and upgraded sensor products. Thus, this would result in evaluating their performance and identifying the most suitable products for various climates and weather conditions. The three evaluated sensors were Autoscope Encore video, Iteris Vantage video, and Wavetronix Matrix microwave sensors. The three sensors performed with high detection sensitivity during ideal environmental conditions with up to 99.9% detection accuracy levels and are suitable for traffic monitoring centres that rely on remote access to the monitored sites and the collected data. However, they were affected by some extremely adverse weather conditions, mainly daytime and nighttime snow, daytime fog, dawn lighting, and strong winds. Overall, the Iteris video sensor performed with the highest detection sensitivity levels, with the Wavetronix Matrix microwave sensor performing similarly under most conditions. Autoscope video provided the highest count accuracies and also provided a much broader data collection capability (p. 52).

Many researches have been done to investigate the effect of traffic signs on a safe distance. Michael et al. (2000) proposed a method to collect headway data in an urban setting that implemented and produced reliable headway data on over 25 000 drivers. Data on the effectiveness of two hand-held roadside signs admonishing drivers not to tailgate are reported. One of these signs that included a reference to "crashes" had a significantly positive impact on drivers' headway. Drivers followed with an average headway of 2.11 s when the sign was absent, compared to an average headway of 2.29 s when the sign was present. When the sign was absent, 49.4% of the drivers complied with the 2-second rule compared to 57.5% when the sign was present. The percentage of drivers who followed with a headway of less than 1 s decreased from 7.3 when the sign was absent to 3.0 when the sign was present (p. 55).

3. CAUSES OF MISDETECTION OF SAFE DISTANCE

The lack of safe distance is a violation detected along the way. Therefore, there will be errors in detecting it when using fixed roadside cameras. Even if the accuracy of the violation detection system is acceptable, it may still fail in some cases, some of which are mentioned below:

1. License plate fraud
2. Sudden lane changing of another vehicle
3. Performing overtaking steps

3.1. License plate fraud

Many drivers eliminate the possibility of recognizing some of their license plate numbers by distorting them or leading to reading another license plate instead. In this case, the safe distance detection system can not detect the violating vehicle. Figure 1 shows an example of license plate distortion.

Figure 1. An example of a license plate distortion (Fararu, 2021)

3.2. Sudden lane changing of another vehicle

Sometimes another driver changes lanes quickly and enters a safe distance between vehicles. Suppose this happens at the moment when these vehicles are in the view of the camera. Instead of the violator vehicle, the rear vehicle may be identified as the violator. This situation is shown in Figures 2 and 3. If vehicle C suddenly enters the distance between vehicle A and B, vehicle A is detected as a violator, while vehicle C is the violator.

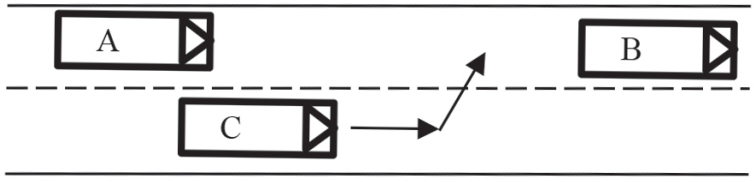

Figure 2. Vehicle C enters the safe distance between vehicles A and B

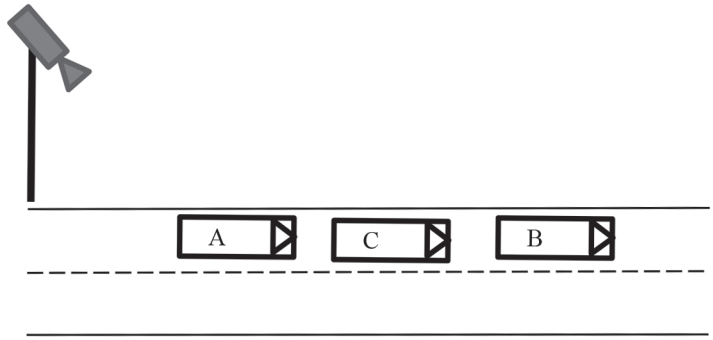

Figure 3. Vehicle A is detected as the violator

3.3. Performing overtaking steps

Sometimes a vehicle intends to overtake the vehicle in front of it. When overtaking, the distance between the two vehicles may be too short, and the system will detect this as a lack of safe distance. This situation is shown in Figures 4 and 5.

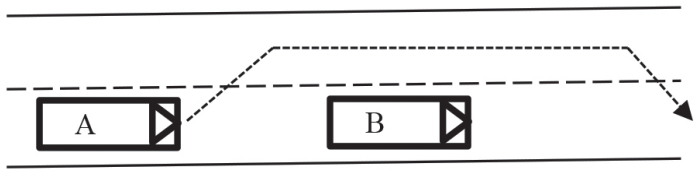

Figure 4. Vehicle A intends to overtake vehicle B

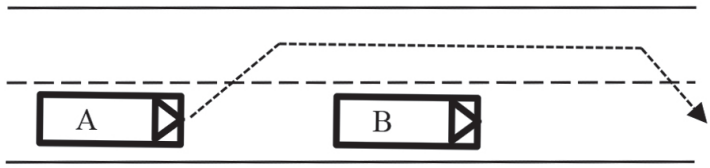

Figure 5. Vehicle A is detected as the violator

4. THEORETICAL FOUNDATIONS OF USING THE POLICE WARNING SYSTEM

In the proposed police warning system, a short message service notes detected violating drivers. If the violation is repeated for a certain number of violations, the driver will be fined for his last violation.

Suppose the accuracy of a system is not sufficient to detect the violation, and the probability of error is high. In that case, it is very unlikely that an error will occur in all violations. This reassures us that the driver must have violated at least once and can be fined for his last violation.

Assuming events A and B are defined to be statistically independent, the probability of occurrence of both events together can be calculated by multiplying their probability, so the probability that a vehicle has been wrongly fined can be calculated from equation 1:

$$P_m = (P_d)^n \quad (1)$$

Where:

P_m is the probability that a vehicle has been wrongly fined,

P_d is the accuracy of a system in detecting a violation,

n is the number of times that a warning message is sent, and

P_e is the acceptable accuracy for fining a driver.

If $P_e < P_m$, there is enough accuracy, and the system can be used for law enforcement. For example, if the acceptable accuracy is one in a million and the accuracy of a system is one in one hundred, with three warnings, an accuracy of one per million is obtained using the relation $(0.01)^3 = 0.000001$

The algorithm used to warn drivers is shown in Figure 6. As shown in Figure 6, a counter is provided for the violations of each vehicle. Whenever a driver commits a violation, a number is added to the counter, and if the counter reaches a threshold number, that driver will be fined. Documents of all registered violations are stored to be presented in court if the driver objects.

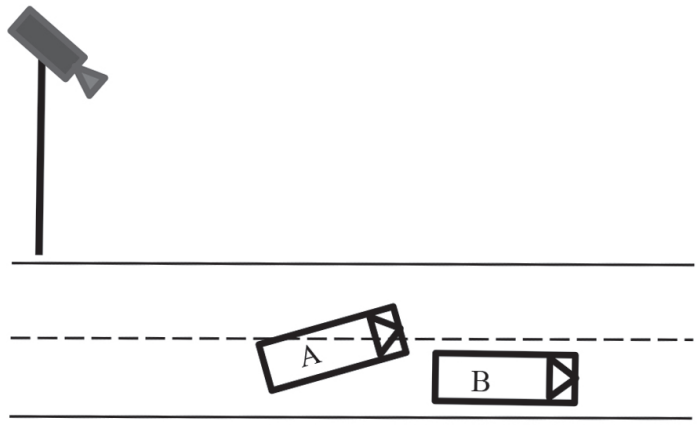

Figure 6. Warning system algorithm

5. SURVEY OF POLICE OFFICERS

The suggestion to use the warning system was discussed with twenty police officers, who were asked to comment on the usage of the pre-enforcement warning system. The survey was conducted using the Likert scale, and they were asked to express their opinion on the following items by stating:

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

All those polled strongly agreed or agreed with the proposed system. The results of this hypothesis test are shown in Table 1. Therefore, we can be sure that the police will welcome the use of this method.

Table: 1 Binomial test of the survey of police officers

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
VAR00003	Group 1	<= 3	0	.00	.50	.000
	Group 2	> 3	20	1.00		
	Total		20	1.00		

6. CONCLUSION

In this research, mathematical relations showed that even if the traffic violator detection system is not accurate enough to detect violator vehicles, the warning system can set the enforcement's accuracy to an acceptable level. In this way, the social consequences of an inaccurate detection system can be avoided. With this research and the establishment of the warning system, a large number of violations that are not currently enforced automatically can be enforced despite the low accuracy of the existing detection systems.

This result can be interesting for traffic police, municipalities and the Highways and Road Transport Organization. Companies active in constructing equipment related to intelligent transportation systems, ITS, can respond to the criticisms caused by the low accuracy of their detection systems by proposing the implementation of a warning system for their products.

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Sažetak

Seyyed Mohammad Sadat Hoseini

Korištenje policijskog sustava upozoravanja za otklanjanje pogrešaka u inteligentnim sustavima otkrivanja prekršaja

Širok raspon raznih tehnologija obuhvaćenih pod generičkom temom inteligentnih prometnih sustava nudi odgovor na mnoge probleme u prometu. Vožnja na repu i neodržavanje dovoljnog razmaka iza drugog vozila među najvećim su uzrocima nesreća na autocestama. Iako postoje inteligentni sustavi za otkrivanje ovakvih prekršaja, nevoljko se koriste zbog njihove nedostatne preciznosti. Ovim se istraživanjem predlaže policijski sustav upozoravanja koji bi uslugom kratkih poruka bilježio vozače zatečene u kršenju pravila. U slučaju ponovljenog kršenja, vozaču se izriče novčana kazna. Koristeći se logikom vjerojatnosti, razvidno je da se predloženim sustavom mogu znatno smanjiti pogreške pri izricanju prometnih kazni. Anketa provedena među policijskim službenicima pokazuje da većina njih pozdravlja predloženi sustav.

Ključne riječi: policijski sustav upozoravanja, inteligentni prometni sustavi, pogreške, vozač koji krši prometna pravila.