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Intelligent speed adaptation: Preliminary results of on-road study in Penang, Malaysia

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ABSTRACT

The first field experiment with intelligent speed adaptation (ISA) in Malaysia was held in December 2010 in the State of Penang. Eleven private cars were instrumented with an advisory system. The system used in the present study included a vocal warning message and a visual text message that is activated when the driver attempts to exceed the speed limit. When the driver decreases the speed, the warning stops; otherwise it is continuously repeated. The test drivers drove the vehicles for three months with the installed system, and the speed was continuously logged in all vehicles. The warning was however only activated in the second month of the three month period. The present study aimed to evaluate the effects of an advisory ISA on driving speed, traffic safety, and drivers' attitude, behavior, and acceptance of the system. To examine these effects, both the survey and the logged speed data were analyzed and explored. The results show a significant reduction in the mean, maximum and 85th percentile speed due to the use of the system. However, there was no long-lasting effect on the speed when the system was deactivated. In the post-trial survey, drivers declared that the system helped them well in following the speed limits and that it assisted them in driving more comfortably. Furthermore, the warning method was more accepted compared to a supportive system, such as active accelerator pedal (AAP). After the trial, most drivers were willing to keep an ISA system.

1. Introduction

Annually millions of road users are killed or injured in traffic accidents [1]. Road-traffic accidents were ranked as the ninth most common cause of death in 1990 and are estimated to be the third most common cause of death by 2020 [2]. Furthermore, fatalities are projected to increase by over 80% in developing countries and by 65% including the developed countries by 2020 [3]. Traffic accidents in Malaysia have been increasing at an average rate of 9.01% per annum from 1974 to 2010 [4,5]. Malaysia is estimated to have over 20 fatalities per 100,000 people in 2020 [3]. Excessive speed is considered to be the major contributory factor to road accidents, injuries and deaths. The strong relationship between vehicular speed and accidents has been demonstrated in several studies over the years. One of the findings indicated that lower speed variance is correlated with fewer accidents (see e.g. [6–11]). Finch et al. [7] declared that reducing speed by 1 km/h can lead to a 3% decrease in accidents resulting in injury and a 4–5% decline in the risk of death. According to Nilsson [9], the number of fatal and serious-injury accidents, for example, decreases by almost 25% when the speed decreases from 55 km/h to 50 km/h. Warner and Aberg [10] declared that approximately one-fifth of all people killed would have survived if drivers had remained within the speed limits.

Analysis of the data recorded by the Royal Malaysian Police revealed that the rate of speeding-related accidents in all states has been increasing noticeably. Speeding was the reason for 11.4% of all crashes in 2010 compared to 0.59% in 2002. Likewise, the percentage of speeding-related fatal accidents per total fatal accidents increased from 19.8% in 2002 to 25.4% in 2010, which is equivalent to a growth of 28.4% [4,12]. Reduction in speeding therefore seems to be a logical way to improve road traffic safety. Improving road safety is a major concern, and road safety advocates around the world dedicate extensive resources to solve speeding problem, mainly through the compliance with speed limits. Currently, various policy efforts, including education (e.g., driving license education and campaigns), enforcement (e.g., police surveillance and speed cameras), or different types of physical measures in the traffic environment such as road humps, are being undertaken to decrease the level of speeding infringements (for a more elaborate overview see [13]). Although, many of the traditional measures have appeared to be successful in the past, analysis of accident data shows that there is still much to be done.

Many of the traditional speed control measures have had limited effectiveness in terms of their site coverage and/or duration. Recent

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studies have shown that, for example, in terms of police enforcement and speed cameras, drivers tend to reduce speed only near the enforcement area and for only a short period of time [14]. Likewise, roadway features designed to reduce speeding tend to reduce speed only in the specific small and limited area [15]. Recent and ongoing developments in technology, including improvements in navigation aids and intelligent in-car systems, provide possible opportunities in assisting drivers to adhere with speed limits. One system that is increasingly gaining attention is the intelligent speed adaptation (ISA).

ISA, which is regarded to be a type of vehicle-based intelligent transportation system (ITS), refers to an advanced in-vehicle electronic driving-aid system. It is a system wherein the vehicle detects the speed limit on a particular stretch of road and can warn the driver if he is exceeding the speed limit, subsequently discourages him from speeding, and/or prevents the speed limit from being exceeded [16]. There are a number of variations for ISA; it could be broadly classified into two main categories concerning its functions: warning or advisory, and limiting or automatic vehicle control [17]. The warning or advisory system provides alarms (auditory, visual, or haptic) when the system identifies and determines that the driver has exceeded the speed limit. The limiting system, also known as the mandatory ISA system, prevents the driver from exceeding the speed limit by adjusting the engine speed or braking control, among others. Most ISA systems use Global Positioning System (GPS) in combination with a digital road map that contains the information about local speed limit. ISA is considered to be a functional device for influencing drivers' speeding behavior, thus contributing to the promotion of road safety. The concept of speed adaptation by in-car systems as safety devices has been studied for nearly 30 years in different countries. In the last decade, several trials involving different types of ISA have been conducted across Europe and Australia. ISA has also been under investigation in many other countries around the world.

In the Netherlands, in a series of Dutch simulator experiments, visual and auditory messages have been employed when a breach of speed limits is detected. The message, which says “you are driving too fast; the current speed limit is XX” was delivered by a female voice and/or alternatively, the text was projected on the simulator screen. The results of these studies showed the positive effect of this type of ISA in terms of its usefulness, although it has a low satisfaction rating among young drivers [18–21]. A study by Aalborg University in Denmark also showed the positive effects of the advisory system on speed limit compliance [22]. The researchers tested a speed limit warning system in which a flashing red LED display and a friendly female voice were given when the drivers exceeded the speed limit. The overall reduction in the average speed was 5–6 km/h. The results of a large-scale Swedish field trial with the “BEEP” system in Borlänge showed that the test drivers behaved more positively in accordance with the traffic rules due to the system. One of the main results of such a trial was an average speed reduction of 0.6–3.4 km/h [23,24].

The results of field trials on ISA in the UK were also promising, showing a reduction in the 85th percentile speed and in the frequency of going over the speed limit. These in turn resulted in a decrease in injury and crash risks [25,26]. In Australia, an on-road evaluation of ISA was carried out from 2002 to 2004 under the TAC Safecar project in the Melbourne area. The results showed that the 85th percentile speed and speeding with more than 5 km/h were reduced by up to 2.7 km/h and 65%, respectively [27]. Experiments in simulator and trial studies with haptic systems (e.g., accelerator pedal and the dead throttle) also showed the positive effects of this type of ISA on drivers' speeding behavior [28–35].

A comparison study of the different types of ISA revealed that even though the limiting system was the most effective and useful in reducing speed, it is not popular among drivers. Instead, the informative and warning system had the highest acceptance [36,37]. Previous trials on ISA throughout the world have demonstrated not only its potential for reducing the risk and severity of accidents, but also its other societal benefits such as improving drivers' interactions with other road users [38]. However, despite the promising overall results of earlier studies there are some arguments in terms of the implementation of ISA, such as which system to use, and the area where the studies have been carried out must also be taken into account. The majority of previous studies were concentrated in Europe with similar road-safety cultures and driving styles. Hence, determining the effect of such a system in a different region with different cultural backgrounds and driving styles would be an issue of interest. The present study is considered to be the first experiment using an advisory ISA system in Malaysia. From December 2010 until February 2011, an ISA on-road study was carried out in Penang, Malaysia. Eleven cars were instrumented with an advisory ISA-system with the intent to study the effects of the system on speed-change, traffic safety, and drivers' attitude, behavior, and acceptance, a survey and analysis of driving data was conducted. The preliminary results obtained in the present study are reported in this paper. Speed-control studies for the ISA system has been started in the Universiti Sains Malaysia in 2007. The present study, serves as a practical evaluation of the advisory ISA system in the region.

2. Materials and methods

2.1. Study design and procedure

The fieldwork experiment was carried out for three months from December 2010 to February 2011 in real traffic in the study area. All the test drivers had an advisory ISA installed in their vehicles. They first drove for one month without activating the system and, their “normal” driving speed was recorded. They then drove for another two months with the system activated for one month and again deactivated for another month, respectively. One week prior to the installation of the device in November 2010, the observation method was employed to measure the average speed for all vehicles. Observations were carried out by an observer who accompanied the driver. The average speed of the vehicle was determined by measuring the travel time. This was done to determine if there is any difference between the participants' usual driving speed with and without the device (side effect of the presence of the device).

The data was logged during the three-month study period. This was started as soon as the device was switched on. Weather and road conditions were also monitored during the on-road study, and data on days with extreme conditions were excluded from the analysis. The analysis was carried out for three specific periods: the month without feedback (warning off), the month with feedback (warning on), and the month when the feedback function was again deactivated (warning off again). These periods are referred to as “before”, “during”, and “after” (for more illustration, see Fig. 1). The subjective data was collected twice during the study through a questionnaire: once at the beginning and again at the second month when the drivers are using the system. To further minimize potential technical and other unpredictable problems during the study with the system, a preliminary test study with one participant was organized for almost two weeks between September 27 and October 12, 2010 before the commencement of the main on-road study [39].

Prior to the main on-road study, all drivers were interviewed separately. Participants were first informed about in-vehicle information

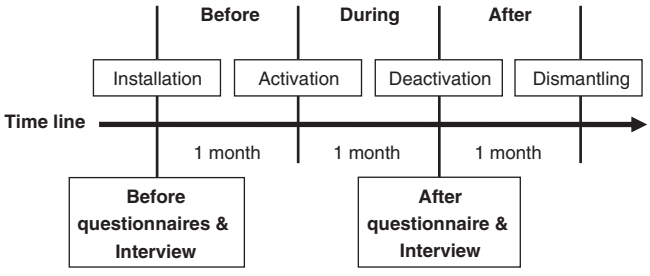

Fig. 1. Schematic view of study's procedure.