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Mutual Assistance System for Automobile Safety

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Abstract: Advanced driver assistance systems (ADAS) are effective measures for reducing the risk of traffic accidents. This paper provides evaluation results for ADAS using the mutual assistance paradigm, in which drivers mutually assist each other for automobile safety. The goal of the mutual assistance system is not only to reduce the risk of traffic accidents but also to improve the driver's attitude. In this research, evaluation of an assistance system was performed with a driving simulator. The experimental results revealed that the automation level of the mutual assistance system heavily changed the driver's attitude. The semi-automatic system was more effective than the fully automatic system for making positive attitude changes. In addition, the semi-automatic system was the most effective for decreasing the driver collision rate. Therefore, the semi-automatic system with some voluntary actions was most suitable for the mutual assistance system and can possibly restrain risk compensation behavior.

Keywords: Automobiles, Mental workload, Human factors, Social and behavioural sciences, Computer simulation.

1. INTRODUCTION

Advanced driver assistance systems (ADAS), such as adaptive cruise control (ACC) systems, are receiving increased attention throughout the world as a way to avoid traffic accidents. However, to maximize the effectiveness of these technologies, it is necessary to decrease the driver's target level of risk by increasing his or her intrinsic motivation level. A target level of risk is the level that a driver is willing to accept while still considering other relevant goals, such as destination arrival time. If the driver's target level of risk is high with ADAS, the driver might exhibit even riskier driving behaviour without these systems. This phenomenon, called risk compensation behaviour, is an important issue for ADAS.

In regards to risk compensation behaviour, Hoedemaeker (1998) reported that very short following distances occurred more frequently when driving with ACC systems than without. In addition, driver reactions were delayed in critical situations when using ACC. However, Vollrath (2011) reported ACCs led to lower maximum velocities and fewer violations of the speed limit.

Trimpop (1996) advocated the use of participative methods such as safety circles to increase intrinsic motivation levels. Additionally, Trimpop (1994) argued that "self-determination, participation, and responsibility can alter people's target level of risk." If the driver's target level of risk is not decreased, the potential increases for risk-taking behaviour while driving. Wilde (1982, 2001) explained this phenomenon in terms of risk homeostasis. Thus, it can be said that the key to receiving the maximum level of benefits from ADAS technology is reducing the target level of risk.

Based on these studies, we suggest that decreased assistance is important for reducing a driver's target level of risk. Also, we believe that participation and self-determination for risk avoidance should be an integral part of any system designed to stimulate a driver's attitude. In our previous work (Kurihashi et al. 2014), we proposed to reduce the target level of risk by using the mutual assistance paradigm. We also conducted two types of experiments (Kurihashi et al. 2015a, b). One of the experiments demonstrated the effect of a mutual assistance system on the recipient driver. The other experiment clarified the effect of the system on the assisted driver. In these two experiments, the participants were each allocated to a recipient driver or an assister, separately. Therefore, we have to collect the data of mutual assistance system in realistic situation toward practical use of it. Realistic situation means participant have to do recipient and assister role simultaneously in onetime experiment.

This paper reveals the effectiveness of the mutual assistance system for a system user in a realistic scenario. The evaluation items used in the analyses are the warning success rate, the mental workload, the attitude change rating, and the collision rate. The knowledges by this paper provide a hint for avoiding overly dependence to some automation systems such as ADAS.

This paper is organized as follows. In Section 2, we introduce the mutual assistance paradigm. In Section 3, we explain the details of the proposed system and the driving scenarios. In Section 4, we describe the environment, objective, and settings of the experiment. In Section 5, the results and related discussions are presented. Section 6 concludes the paper.

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2. MUTUAL ASSISTANCE

In our previous research (Kurihashi et al. 2015a), we noted that the driver assistance system can be subdivided into the following three types, adopted from Japanese disaster management: individual assistance, mutual assistance, and public assistance. Fig. 1 shows the relation among these three assistance types.

In Japanese disaster management, individual assistance means self-help by the victims themselves, e.g., voluntary evacuation and emergency food preparation. Mutual assistance means that everyone helps each other voluntarily, e.g., helping others in evacuation with mutual cooperation. In mutual assistance, the participants can take one of two roles: one person is the recipient, and the other is the assister. Public assistance is provided by public organizations. Such assistance includes the provision of free food and fund-raising activities. In the White Paper on Disaster Management 2013 in Japan, it is recommended that assuring the safety of individuals should be accomplished by combining these three types of assistance.

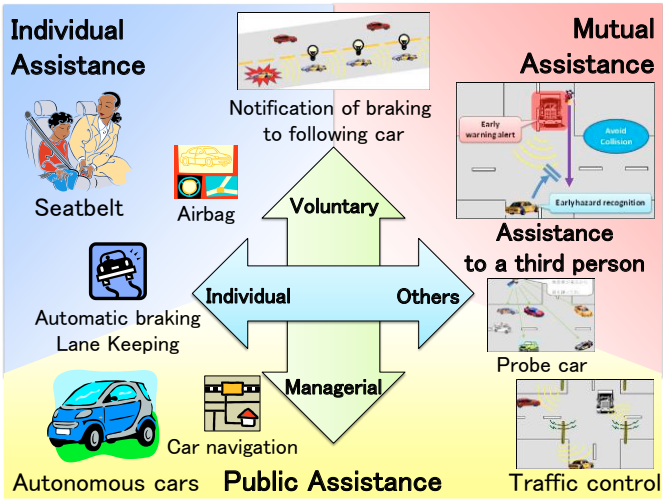

Fig. 1. Diagram of the three types of assistance provided by driver safety systems. [Adapted from (Kurihashi et al. 2015a)]

In recent studies of the Advanced Safety Vehicle (ADAS), a number of safety systems have been proposed. However, such systems are mostly classified into either individual assistance (e.g., automatic braking systems and lane keeping systems) or public assistance (e.g., autonomous cars and traffic control systems).

The authors further proposed reducing the target level of risk by using “mutual assistance”, which is a phrase that is often used in the disaster management field in Japan that means that “everyone helps each other”.

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3. SYSTEM AND SCENARIOS

3.1 Proposed System

We now present more details of the proposed system. First, we should note that vehicles are driven on the left-hand side of the road in Japan, and so a right turn in Japan is equivalent to a left turn in the USA. In the case of Fig. 2, the car driver (recipient) turning right cannot see the oncoming motorcycle (potential victim), because the view of the oncoming vehicle is blocked by the truck (assister). To prevent such potential accidents, we proposed a mutual assistance system that would allow the assister (truck) to provide a warning alert to the recipient regarding the existence of a vehicle (motorcycle) in his blind spot. This system presupposes that charge-coupled device (CCD) cameras (or millimetre-wave radar) have been installed on the side-view mirrors of vehicles in order to register the presence of vehicles in the vehicle’s blind spot. Additionally, we assume that the warning is provided by a change in the assister’s vehicle colour from its actual colour to an unambiguous colour in the CCD image. Automobile body colour changes can be achieved by technologies such as Fun-vii provided by TOYOTA. Byung (2014) introduced "This car has a specific appearance which is different from other typical concept cars in prominent motor shows".

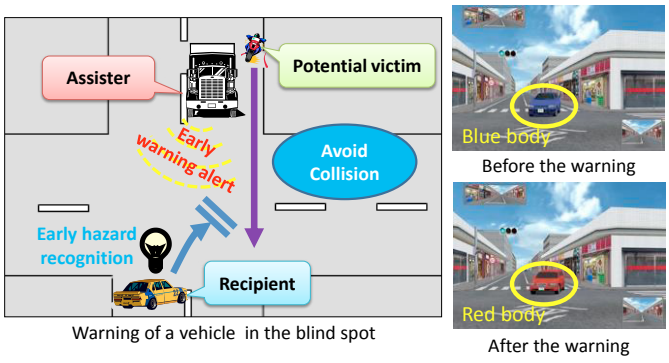

Fig. 2. Proposed mutual assistance system. [Adapted from Kurihashi et al. (2015b)]

The envisioned merits of this system are as follows:

- ✓ The driver as an assister can participate in a safety-related activity by issuing a warning. This would decrease the target level of risk for the assister.
- ✓ The system can provide mutual assistance independently of road-to-vehicle or vehicle-to-vehicle communication. This would eliminate the threat of malevolent cracking (sound interference) in wireless communication technology.
- ✓ The system can provide a warning by visual information, which is said to account for about 80% of all the information that a human being receives.