DEVELOPMENT OF A DRIVING SIMULATOR FOR VIRTUAL EXPERIENCE AND TRAINING OF DRUNK DRIVING

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ABSTRACT

The aim of this study is the development of a driving simulator for the virtual experience of drunk driving and education on its dangers. Towards this end, visual effects specially designed via a real-time image generation engine were implemented in the graphic database for distorted-vision generation, space perception ability impairment, and downscaled peripheral-vision scope. A steering wheel and brake model were tuned to simulate delay in the driver's decision making, muscular control, and perception reaction time (PRT).

The simulation participant can choose the blood alcohol content (BAC) level that he/she wants to experience through a selector button in the center fascia, and can experience the dangers of drunk driving in a virtual environment. Different driving scenarios on an urban road, a rural road, and an expressway were developed for a more comprehensive experience. Each driving scenario was designed to include various visual effects and vehicle dynamics simulations of drunk driving. Through these contents, the simulation participant can indirectly experience the physical and physiological changes that occur in the human body during drunk driving, and can develop alertness in the event of a traffic accident caused by drunk driving.

An instructor monitoring and control system was developed to simultaneously control and monitor multiple driving simulators. This system can record and replay the road situation and the driving behavior of each participant, and can finally report the training result.

This study is expected to contribute to the prevention of traffic accidents caused by drunk driving by offering education on the dangers of drunk driving in a safely controlled environment. The future work should include the implementation of more realistic visual effects and vehicle dynamics simulations of drunk driving on training contents, and broad application in the field of driver training.

KEYWORDS: habitual drunk drivers, driving simulator, drunk driving, blood alcohol content (BAC), perception reaction time (PRT)

INTRODUCTION

The driving task consists of perception, cognition-decision, and motor response. Driving under the influence of alcohol (DUI) impairs a wide range of skills necessary for carrying out these tasks. DUI is dangerous, and drivers with high blood alcohol content (BAC) are at a much higher risk of causing traffic accidents, highway injuries, and vehicular deaths. According to the estimates made by Insurance Institute for Highway Safety (2004), the relative risk of death in single-vehicle crashes for drivers with a high BAC is 385 times that of a zero-BAC driver, and for male drivers, the risk is 707 times that of a sober driver.

In South Korea, despite the growing public awareness that “drunk driving is a serious crime and is unacceptable,” the number of traffic accidents caused by drunk driving is hardly ever abated. Above all, over 30% of DUI offenders are arrested two times or more. The number of habitual drunk drivers tends to increase (Table 1). Moreover, considering the number of potential drunk drivers who have not been arrested, the problems related to repeated habitual drunk driving are more serious.

According to a survey jointly conducted by Kanagawa Prefectural Police Headquarters and National Hospital Organization Kurihama Alcoholism Center (2009), 76.8% of all people have a history of drunk driving while 56.1% do not have an arrest history related to drinking. The results of the Alcohol Syndrome Screening Test (AUDIT) conducted for persons with a history of drunk driving indicate that 41.4% of the people who took the test were suspected of being alcohol-dependent. The percentage of persons with dangerous drinking habits was 32.6%, and thus, about 70% of them had alcohol-related behavioral problems.

In 2004, 16,694 traffic deaths and 248,000 injuries in the United States were related to alcohol-impaired driving (AID) (NHTSA, 2005). Over the past decade there has been little change in the number of alcohol-related deaths, although alcohol’s contribution as a percentage of all motor vehicle deaths has decreased slightly (NHTSA, 2005). The economic impact of alcohol-impaired crashes in the United States in 2000 was estimated to be $51 billion (NHTSA, 2003). The risk of a crash increased when drivers were under 40, were driving at night, and were driving on less traveled roads (Keall et al., 2005), as well as among people who engaged in heavy and/or binge drinking (Quinlan, 2005). Hingson and Winter (2003) estimated that drivers take more than 82 million DUI trips per year at blood alcohol concentrations (BACs) of 0.08 or higher, representing perhaps 10% of all trips where at least some driver alcohol use is present.

Legal sanctions, such as driver's license suspension, license revocation, and court-ordered alcoholism treatment, have been designed to deter drunk driving. Driver's license suspension and license revocation seem to be the most effective deterrents among the general driving population. The most effective means of reducing the cases of DUI and crashes, however, was a combination of license suspension and interventions, such as education, psychotherapy counseling, and specific follow-up schemes like Ignition Interlock and Driver Alcohol Detection System for Safety (DADSS).

According to Sadler et al. (1991), a DUI conviction should serve to identify problem drinkers and to guide or coerce them into alcoholism treatment. The alcoholism treatment for DUI offenders can range from short-term educational sessions to therapy programs lasting for at least one year.

Korea National Police Agency (KNPA) and Korea Road Traffic Authority (KoRoad) gave directions to all the branches of KoRoad to set up a special class for the drunk drivers in the course who have been penalized. In 2006, a special course about drinking was organized in all the branches of KoRoad. In the course, a lecture and an important training session related to the dangers of drunk driving were conducted. In 2012, a special class for habitual drunk drivers will be added to the new curriculum, in which they have to simulate the drunk-driving experience through a driving simulator, and in which they will receive intensive education about the dangers of drunk driving through indirect experience. It will be mandatory for a driver with more than 40 point black marks from drunk driving.

Table 1 DUI related Traffic Safety Facts

KNPA, 2010

Year	DUI accidents	Severity		Arrests for DUI			
	Total	Killed	Injured	Total (Percent)	1 time (Percent)	2 times (Percent)	3 times or more (Percent)
2005	26,460	910	48,153	385,178 (100%)	273,009 (71%)	85,654 (22%)	26,515 (7%)
2006	29,990	920	54,255	353,580 (100%)	238,589 (67%)	84,947 (24%)	30,044 (8%)
2007	28,416	991	51,370	412,482 (100%)	269,618 (65%)	100,769 (24%)	42,095 (10%)
2008	26,873	969	48,497	434,148 (100%)	276,637 (64%)	108,535 (25%)	48,976 (11%)
2009	28,207	898	50,979	327,606 (100%)	200,828 (61%)	83,731 (26%)	43,047 (13%)

Various devices have been developed for the simulation of the drunk-driving experience. For example, drunk goggles simulate the effects of impairment, including reduced alertness, slowed reaction time, confusion, visual distortion, alteration of depth and distance perception, reduction of peripheral vision, poor judgment and decision making, and lack of muscular coordination. They represent a different simulated BAC of approximately 0.04-0.25. A similar device is the simulated-drunk-driving-experience vehicle, a battery-powered minivehicle that reacts with delayed steering, braking, and acceleration, simulating the effects of a vehicle being driven by a distracted or impaired driver.

This study was conducted for the development of a driving simulator for the virtual experience of and education on the dangers of drunk driving (DUI-DS). DUI-DS was developed by combining the advantages of the drunk goggles and the drunk-driving-experience vehicle. To accomplish this, specially designed visual effects via a real-time image generation engine were implemented in a graphic database for distorted-vision generation, space perception ability impairment, and downscaled peripheral-vision scope. The steering wheel and brake model were tuned to simulate delay in the driver's decision making, muscular control, and perception reaction time (PRT).

The characteristics of DUI-DS are a simple user interface and various simulated traffic environments. The participant can choose the BAC that he or she wants to experience through a selector button in the center fascia, and can experience the dangers of drunk driving in a virtual environment. Different driving scenarios on an urban road, a rural road, and an expressway were developed for a more comprehensive experience. Each driving scenario was designed to include various visual effects and vehicle dynamics simulations of drunk driving.

Through these contents, the participant can indirectly experience the physical and physiological changes that occur in the human body caused by drunk driving, and can develop alertness in the event of a traffic accident caused by drunk driving. An instructor monitoring and control system was developed to simultaneously control and monitor multiple driving simulators. DUI-DS can record and replay a road situation and the driving behavior of each participant, and can finally report the training results.

This study is expected to contribute to the prevention of traffic accidents caused by drunk driving by offering education on the dangers of drunk driving in a safely controlled environment. The future work should include the implementation of more realistic visual effects and vehicle dynamics simulations of drunk driving in the training contents, and broad application in the field of driver training.

METHOD

How Alcohol Affects Humans

It is not the direct effect of alcohol on driver performance or driver behavior that makes it so important in traffic safety, but the changes in crash risk that flow from these changes in performance and behavior.

Moskowitz and Fiorentino (2000) reviewed a literature on just one aspect, namely, how alcohol affects skills related to driving, identified 1,733 titles. These include cognitive tasks, critical flicker fusion, divided attention, driving on simulators, drowsiness, perception, psychomotor skills, reaction time, tracking, vigilance, and various visual functions. Strong evidence showed performance declines for some driving-related skills at any measured BAC > 0. Performance declines were reported by the majority of studies for BAC ≥ 0.05%, and for 95% of studies for BAC ≥ 0.08%. Alcohol has major effects on behavior, including reducing inhibitions and caution, and increasing aggressiveness and risk taking. Impairment has been defined as a statically significant decrease in performance under alcohol treatment from the performance level exhibited under placebo treatment.

Alcohol is a type of tranquilizer that can be easily acquired in daily life. Drinking a small quantity of alcohol (BAL ≤ 0.03%) will not have a conspicuous effect on the body, but drinking more than a certain quantity (BAL 0.05%) will affect the central nervous system and will impair the PRT, space perception ability, sense of equilibrium, saccadic eye movement, fixation eye movement, and accuracy of motion, as well as the concentration, wariness, attention, and emotional control, which may lead to irrational driving behaviors. The effects of alcohol drinking on the body can be divided into the following steps:

Step 1: The visual perception ability is impaired (BAL≥0.05%).
Step 2: Judgment is impaired (BAL ≥ 0.07%, about 50% of the value before drinking alcohol).
Step 3: Operation errors begin to occur (BAL ≥ 0.15%).

Furthermore, the effects of alcohol drinking on the driving behavior are shown in Table 2.

Table 2 Performance and behavior characteristics that have been associated with increasing BAC levels (Leonard Evans, 2006).

BAC	Performance and behavior change
0.01%	Normal actions hardly influenced.
0.02%	Change in social behavior, mild euphoria, relaxation, increased gregariousness.
0.05%	Feeling good, less inhibited, altered judgment, lowered alertness
0.07%	Judgment impaired, likely to take risks and action not taken when sober, release of inhibitions, impulsive behavior, and slight decrease in fine motor skills.
0.10%	Slower reaction times and impaired motor function, less caution, slightly slurred speech, increased aggressiveness.
0.15%	Large, consistent increases in reaction time, balance impaired, slurring of speech.
0.20%	Major memory impairment
0.27%	Confusion, slurred speech.
0.30%	Double vision may occur; most drinkers become unconscious or fall asleep at this level and difficult to awaken.
0.40%	Barely conscious.

System Requirement Review

System requirements for DUI-DS are defined as following Table 3.

Table 3 System requirements for DUI-DS

	System requirements	Importance
General requirement	- Easy to operate - Ease to move and install - Ease to get (low cost and maintainability) - Easy to upgrade - Minimize the Simulator Adaptation syndrome (SAS)	Required
Image generator	- Average frame rate: 60 fps (minimum 30fps) - Effects of impairment - Reduced alertness - Confusion - Reduction of peripheral vision - Visual distortion - Speed effect - Alteration of depth and distance perception	Required
Vehicle dynamic	- Delayed steering, braking, and acceleration	Required
Road environment and driving scenario	- Surround vehicle around weaving or diverging area - Dangerous passing maneuverer - Straddling the centre line - Making wide turns - Tailgating - Turn on/off headlight, turning and hazard lamp - Signal control at the dilemma zone	Required

System Feature

As shown in Figure 1, DUI-DS is composed of three subsystems: the main system, the monitoring and control system (below, control console), and the presentation system. The main system and the monitoring and control system exchange data via 1000 Mbps Ethernet (TCP/IP). The monitoring and control system records with a frame grabber the faces of the trainees from the two CCD cameras installed on the dashboard and the images on the front monitor. Any peculiar behavior or situation detected while driving are bookmarked through the cue switch and are stored with the driving video and driving behavior data synchronized so that the situations can be explained to the trainees after the training. Furthermore, when dangerous situations such as sudden braking (deceleration: 0.3 g or greater) and sudden steering (rotation angle velocity: 20 deg/sec or faster) are detected, or when crashes with road facilities are detected, the video and vehicle data are automatically saved, and the dangerous situation or accident can be replayed later.

The image generation engine not only realistically reproduces the road environment (e.g., day/night, fog, rain, snow, shadow) but also produces special visual effects, such as peripheral-vision reduction, visual distortion, and alteration of depth and distance perception, which occur after alcohol drinking. In particular, if the 3D mode is activated and the trainees wear 3D goggles, they can realistically experience drunk driving through the 3D videos that are generated in real time by the image generation engine.

Figure 1 System feature

Design of 3-Dimensional Road Space

Terrain

DUI-DS consists of four types of terrains: urban road (10 km), rural road (15 km), expressway (10 km), and exercise road (10 km). These terrain types were developed based on the data collected through road design drawings, aerial photographs, and field surveys. The urban road was characterized by a complex traffic situation consisting of concentrated buildings on the road, crossroads, crosswalks, pedestrians, and bicycles; the rural road by a simpler and darker traffic environment compared to the urban road; and the expressway by the situations that may occur during the converging and diverging on an outskirts beltway that connects the urban area with heavy traffic to the surrounding cities. The exercise road was an expressway composed of straight and slowly curving sections. Figure 2 is a terrain sample screen shot.

Traffics signal and road marking

Traffic signals were set to naturally reproduce situations such as traffic in a crossroads dilemma zone and the unexpected appearance of signal-violating vehicles and pedestrians.

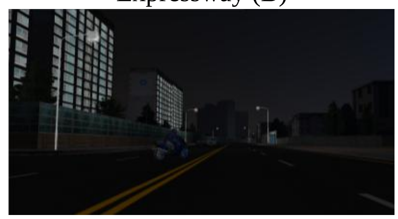
Lighting

For the road lighting environment, not only nighttime road environments such as streetlights, building lights, shadows, and lights from the nearby vehicles can be controlled based on the fact that most drunk-driving accidents occur between 7 p.m. and 1 a.m.; the headlights (low/high) and tail, stop, turning, and hazard lights can also be controlled in real time through the multifunction switch at the driver's seat.

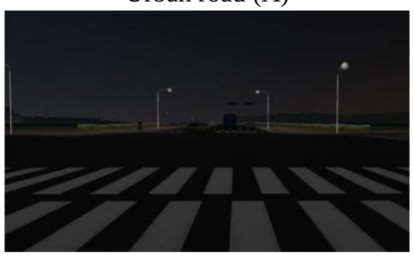
Expressway (A)

Expressway (B)

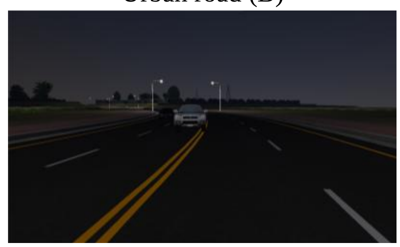
Urban road (A)



Urban road (B)



Rural road (A)



Rural road (B)

Figure 2 Terrain sample screen shot

Crosswalk (Highway)

Curve section (Highway)

On ramp (Expressway)

Tunnel(Expressway)

Figure 3 Special visual effect

Vehicle Dynamics

Figure 4 shows a block diagram of the driver model. A steering wheel and brake model were tuned to simulate delay in the driver's decision making, muscular control, and perception reaction time (PRT). Table 5 shows default values and ranges for delayed brake reaction, delayed steering wheel reaction.

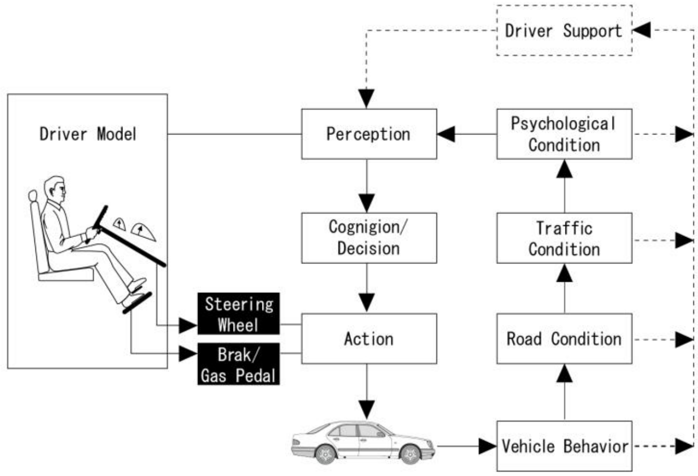


Figure 4 Block diagram of the driver model (DUI-DS)

Driving Scenarios and Unexpected Events

The driving scenarios consisted of four types of roads (exercise road, urban road→rural road, urban road→expressway, and expressway) with a total length of 40 km. Table 4 shows the events or driving tasks included in each driving road.

Table 4 Driving scenarious and unexpected events

Scenario Name (Driving Distance)	Scenario Number	Description
Excerise (10 km)	000	The exercise road was designed for practicing basic operations such as acceleration, deceleration, lane change, and curved-road passage on a virtual high-grade motorway.
Urban→rural (10 km)	101	A child walks across a danger zone.
	102	A motorcycle on the left road suddenly turns left and crosses the road.
	103	A bicycle running along the shoulder of a road suddenly loses balance and enters into the road before returning to its original position.
	104	On a crossroad, a vehicle running in the opposite direction passes across the front of the simulation participant's car and turns right.
	105	On a sharply curving road, the simulation participant encounters a vehicle in the opposite lane that breaks away from the lane.
Urban→ Expressway (10 km)	201	The simulation participant meets a vehicle running on the main lane at the converging point to the outskirts expressway from the urban road.
	202	While the simulation participant is driving at a high speed, the front vehicle suddenly decelerates.
	203	The simulation participant encounters an accident site while passing through a tunnel, and he/she quickly decelerates and changes lanes.
	204	A vehicle stuck in the traffic at the shoulder suddenly transfers to the main lane.
	205	At an off ramp, a guiding voice says "Go straight" and then suddenly says "Go out to the right road."
Expressway (10 km)	301	The simulation participant accomplishes certain missions while following the front car.
	302	While following the front car, the simulation participant encounters traffic congestion, and the surrounding cars suddenly decelerate.

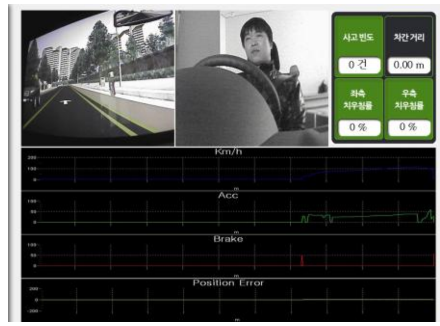
Monitoring and Control system

The monitoring and control system has two modes: the real-time mode, in which one can monitor in real time different driving scenarios and all the data related to driving; and the presentation mode, in which one loads the data saved in the real-time mode to analyze the general driving behavior, driving actions, and information for each driving scenario, and to generally evaluate and print the driving results. Figure 5 shows the GUI configuration of the application in the real-time and presentation modes.
The simulation participant can choose the BAC level that he/she wants to experience through a selector button in the center fascia, and can experience the dangers of drunk driving in a virtual environment. Fig. 4 shows the user interface of the monitoring and control system.
For the effects of alcohol drinking on the body, the BAC range of 0-0.20% was divided into four levels. The defaults for delayed brake reaction, delayed steering wheel reaction, downscaled peripheral-vision scope, impairment of discrimination (vision), and wave effect were defined based on the experimental values in accordance with each drinking indicator. The settings can be randomly adjusted in real time by the instructor. The delays in various reactions and the visual special effects according to the drinking indicator are shown in Table 5.

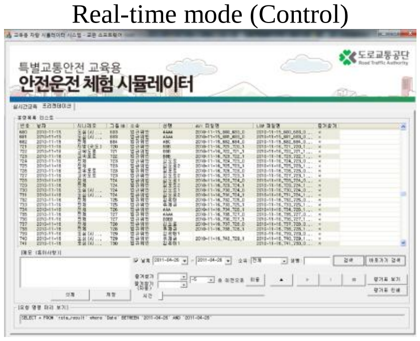
Table 5 Settings for special effects according to BAC

	Default	Remarks
Delayed brake reaction	Adjustable range: 0.00-1.00 sec 0.00-0.05% (0.1 sec) 0.05-0.10% (0.2 sec) 0.10-0.15% (0.3 sec) 0.15-0.20% (0.4 sec)	Delay in brake reaction and increased braking distance due to such delay are reproduced.
Delayed steering wheel reaction	Adjustable range: 0.00-1.00 sec 0.00-0.05% (0.2 sec) 0.05-0.10% (0.3 sec) 0.10-0.15% (0.4 sec) 0.15-0.20% (0.5 sec)	Danger avoidance ability and lane maintenance ability to horizontal dangers due to delayed steering wheel reaction are reproduced.
Downscaled peripheral-vision scope	Adjustable range: 0-100% 0.00-0.05% (10%) 0.05-0.10% (20%) 0.10-0.15% (30%) 0.15-0.20% (40%)	The objects in the peripheral vision appear blurred, which decreases the sense of speed and impairs the ability to respond to sudden situations from the sides of the road.
Impairment of discrimination	Adjustable range: 0-100% 0.00-0.05% (10%) 0.05-0.10% (20%) 0.10-0.15% (30%) 0.15-0.20% (40%)	Impairment of vision due to drinking is reproduced. As the discrimination of the objects at the front is impaired, it affects the judgment ability in various situations.
Wave effect	ON/OFF	Decline of the sense of equilibrium due to drinking is reproduced. Objects are shaken, and lights appear scattered.

Real-time mode (Control)



Real-time mode (Monitoring)



Presentation mode (Analysis)

Presentation mode (Replay)

Figure 5 User interface for monitoring and control system

System Test and Validation

In the early stage of its development, DUI-DS accommodated the experimental values for the special effects and reaction times acquired from various literatures. Then driving experiments were performed by a driving simulator with 25 subjects (19 males and six females, mean age: 34.8, standard deviation: 6.5) who drank alcohol, after which simulator experience was provided to 200 subjects who did not drink alcohol. After the simulator experience, the subjects were made to fill out a survey form. The experiment with the 25 subjects who drank alcohol was conducted to acquire data for setting the special effects and the brake and steering handle reaction times of DUI-DS. Meanwhile, the experiment with the 200 subjects who did not drink alcohol was conducted to acquire opinions on drunk-driving experience through a simulator.

The subjects who drank alcohol were made to carry out the exercise and to drive through the urban→rural scenarios before drinking alcohol, and when they reached the BAC level of 0.05-0.1% after drinking alcohol, they were made to drive through the same scenarios again. The measurements of the reaction times before and after alcohol drinking revealed that the mean PRT decreased by about 0.087 sec ($t = 1.73$, $p < .05$) after drinking alcohol.

RESULTS AND DISCUSSION

This study was conducted to apply experiential education using virtual-reality technology to the special traffic safety education course for chronic drunk drivers, to improve the education effects. Although drinking glasses are an effective experiential tool, experiencing a driving simulator with drinking glasses aggravates the simulator sickness and provides a burden to the trainees. When the DUI-DS that was developed in this study, was tested with 200 trainees, at least 85% of the participants claimed that the experiential education using virtual reality was “useful” or “(very) effective”. Figure 6 shows one of the questionnaire results.

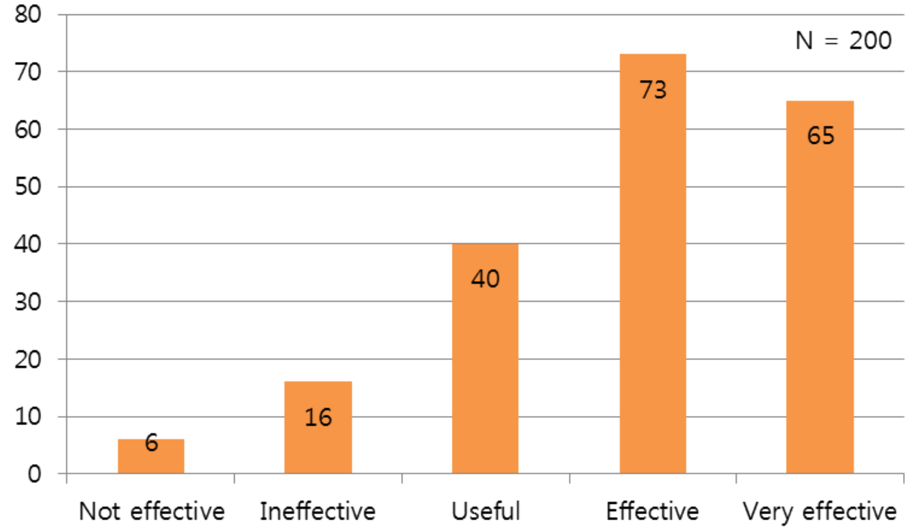


Figure 6 Expectation of the DUI-DS at educational sites

Strictly speaking, tuning the vehicle dynamics model of the driving simulator to delay the steering wheel and brake reaction to up to 0.4 sec is not a body reaction due to alcohol ingestion. It is, however, the most effective method in a situation where people cannot be educated after drinking alcohol. The education scenarios of DUI-DS reproduce the PRTs in complex situations where various traffic conditions are combined instead of simply experiencing reactions, and there have been few negative opinions about it.

CONCLUSIONS AND FUTURE STUDY

It can be concluded that the driving simulator for the drunk-driving experience that was developed in this study is one of the most effective tools for indirectly experiencing the dangers of drunk driving for general drivers as well as chronic drunk drivers. Furthermore, as DUI-DS has all the functions of general driving simulators, it is expected that the addition of educational contents to it will allow it to be used for driving practice, hazard perception training, and aptitude tests.

DUI-DS will be test-operated in the field until December 2011; opinions about it will be gathered from the trainees, driving educators, and psychological therapists; and the related problems will be improved. In 2012, it will be introduced to the nationwide education sites of Korea Road Traffic Authority. Korea National Police Agency submitted a bill to the National Assembly that requires the inclusion of experiential education through DUI-DS in educational courses for drunk drivers. A limitation of DUI-DS is that long-time experience is difficult due to the simulation adaptation syndrome (SAS), which is a common problem of all driving simulators. The test operation revealed that around 10 min is appropriate as a trainee driving time, and it is recommended that the education not be conducted for more than three times in a row. As a follow-up study, measures for minimizing the SAS are being examined.

ACKNOWLEDGEMENTS

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Oct. 28 (Thu)

T_AP00712 **Development and Application of the Non-stop Overweight Control System Using HS-WIM**
Jiwon Kim, Total Pave System Co. Ltd., Republic of Korea

T_AP00684 **Construction of Overhead-view Images Using Single Camera at a Road Intersection**
Naoya Kawai, Shizuoka University, Japan

T_AP01223 **Image Infomation Collection of CCTV Dead Zone Using Wireless AP**
Eui-Duk Hwang, DB Communication & Systems, Republic of Korea

TP 088 Role of Government and Organizational Issues

Oct. 28 (Thu) 14:00~15:30, C 109

Moderator: Roger Pagny, Ministry of Ecology, Energy, Sustainable Development, and th, France

T_AP01344 **A Study on a New Transportation System for Seoul**
Chang-Yong Jung, University of Seoul, Republic of Korea

T_AP01064 **Monitoring and Analysis of Bus-only lane Policy & Lane Control System on Gyeongbu Expressway**
Hyungsuk Lee, Korea Expressway Corporation, Republic of Korea

T_EU00280 **Parameters Determining Route Choice in Pedestrian Networks**
Franziska Wolf, ifak - Institut f. Automation und Kommunikation e.V. Magdeburg, Germany

T_AP01518 **Master Plan and Basic Design for ITS of Incheon Free Economic Zone**
Yongseok Hahn, Yooshin, Republic of Korea

T_EU00871 **The Architecture for GNSS Enabled Service Converge**
Rasmus Lindholm, ERTICO - ITS Europe

T_AP01420 **A Study on the World Geodetic System-84 Environment**
Jae-Hyun Han, The Korea Transport Institute, Republic of Korea

TP 090 Evaluation Tools and Strategies - Part (II)

Oct. 28 (Thu) 14:00~15:30, C 201

Moderator: Takaaki Sugiura, Mitsubishi Research Institute, Inc, Japan

T_EU01040 **Evaluating the Public Transport Priority System: Identifying Background Data Impact**
Marko Matulin, Faculty of Transport and Traffic Sciences, Croatia

T_AP01200 **Development of the Safety Evaluation System for Korea Rural Highways**
Dongmin Lee, The Korea Transport Institute, Republic of Korea

T_EU01041 **Data Collection Method Analysis for Evaluation of Public Transport System Performances**
Štefica Mrvelj, Faculty of Transport and Traffic Sciences, Croatia

T_AP00432 **Quantitative Evaluation of Accidents due to a Complex Traffic Environment**
Ilki Hong, Innosimulation Inc., Republic of Korea

T_AP00493 **Development of the Assurance Test System for the Nationwide Interoperable Transportation Card in Korea**
You Jin Kim, Seoul Women's University, Republic of Korea

T_AM00356 **Evaluation of Geofences Technology Using the Weighting for the Transit Time Method Considering Its Variability**
Caio Fontana, University of Sao Paulo, Brazil