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Development of Driving Simulator For
In-Vehicle Information System (IVIS) Evaluation:
Progress & Challenges

Mohd Firdaus Mohd Siam1 *, Mohd Hafzi Md Isa2, Muammar Quadaffi Mohd Ariffin3, Nurulhana Borhan4, Abdullah Sukardi5, Wong Shaw Voon6

1,2,3,4,5,6Malaysian Institute of Road Safety Research (MIROS)
43000 Selangor, Malaysia

*Corresponding author’s email: mfirdaus@miros.gov.my

Abstract - The Malaysian Institute of Road Safety Research (MIROS) has embarked on the development of driving simulator. The simulator, which is Mini Driving Simulator Cabin (CabinDS), can be reconfigured easily to suit various road safety research requirement. The purpose of this on-going project is to develop a driving simulator that is suitable for In-Vehicle Information System (IVIS) evaluation. The main components of the integrated system of CabinDS used in this project were steering wheel, pedals, transmission, full car cabin, LCD projector and screen, computer, simulation software and sound system. Detection Response Task (DRT) was used as a method to assess increased demand while driving when using IVIS as secondary task.

Keywords - Driving simulator, in-vehicle information system, road safety.

I. INTRODUCTION

The number of fatalities due to road accidents in Malaysia has been consistently above 6,000 over the past few years [1]. In year 2012, 6,917 fatalities were recorded due to road crashes, with an average of 19 people were killed every day [2]. This alarming figure is not only happening in this country but also worldwide, in which road traffic injury is the eleventh leading cause of death, and more than one million are killed every year because of road crashes [3]. A previous study had shown that human errors are the major contributing factor, which is about 90% of the road traffic accident [4].

The technology involving In-Vehicle Information System (IVIS) is rapidly changing. Vehicles must be designed to be compatible with the users and not distract them while driving [5]. IVIS can cause distraction by diverting the driver’s attention from the driving task [6]. Driver distraction is a significant contributor to road traffic accidents [7,8]. Naturalistic driving studies have demonstrated that drivers have a tendency to spend a vast amount of driving time with secondary tasks. According to the research, about 23% of all crashes and near crashes were caused by distraction due to secondary tasks [9].

One of the prominent tools to study human factor related issues is driving simulator. It is able to simulate a virtual driving environment and resemble real driving condition [10]. Advantages of using driving simulator as compared to real road experiment are controlled and repeatable environment, safety purposes and cost reduction [11].

The objective of this project is to develop driving simulator so called as Mini Driving Simulator Cabin (CabinDS), purposely to evaluate the effect of IVIS usage while driving, as a secondary task demand on selective attention. Types of IVIS are driving-related tasks, such as operation of navigation aids and the acquisition of traffic information from an in-vehicle system. Meanwhile, non-driving-related tasks cover the operation of media players, talking with mobile phone and internet browsers usage.

Nevertheless, this project is still ongoing. The paper presents the content on the project progress and challenges.
II. METHOD

A. Participants

30 participants (15 females, 15 males) took part in the study. Their ages ranged from 25 to 45 years old, experienced and non-professional drivers. They agreed to take part as volunteers and they had valid driving licences. They were also able to drive manual transmission.

B. Driving Simulator Development

CabinDS consists of some components that are integrated into one system. The main components of the integrated system of CabinDS are steering wheel, pedals, transmission, full car cabin, LCD projector and screen, computer, simulation software, video camera and sound system. The overview of the integrated system of CabinDS is shown in Figure 1. In this project, OktalScanner Studio was used as simulation software. Three different roadways were designed in the simulation study, which were expressway, off-ramp and curve road.

The driver would generate the control inputs from the steering wheel, pedals and transmission, which would be detected from inside the simulator as the primary of the simulator. Vehicle dynamic model was created using a systematic algorithm that functioned to measure, control and integrate the signals in the simulation process.

The CabinDS steering wheel was a modified and integrated the Logitech G27 steering wheel and changed using the real car steering wheel. The steering wheel performed two functions, which were to measure the angle of steering wheel rotation and generate a real car feeling, which would be force feedback mechanism with helical gearing. The steering had a 900 degree wheel rotation.

The visual display scene was projected on the white screen through one projector. The horizontal field of view was 45.6° and vertical field of view was 30.6°. The CabinDS included a desktop computer that controlled and integrated the overall simulator system, in terms of hardware and software.

Scanner Studio was used as the simulation software in the development of CabinDS. It is a comprehensive driving simulation software package. It can be used for vehicle ergonomics and advanced engineering studies, as well as for road traffic research and development. It is also used for human factor studies and driver training. Scanner Studio consists of 5 main modes, which are Vehicle, Terrain, Scenario, Simulation and Analysis [12].

C. Detection Response Task (DRT)

Two types of DRT were used in the study, which were tactile and head-mounted. The stimuli were presented at temporal intervals randomly, and uniformly distributed between 3 and 5 seconds. In the head-mounted DRT (HDRT), the visual stimulus was presented by means of a single LED attached to the head.

The tactile version of the DRT was referred to as the Tactile DRT (TDRT). The tactile stimulus was presented by means of a small electrical vibrator (tactor). The tactor was placed on the driver’s shoulder using medical tape. Participants would respond by pressing a microswitch attached to the right index finger. The response was made by pressing the switch to the steering wheel.
D. Secondary Tasks

There are three types of secondary tasks that were used in the study, which are n-back, SURT, and navigation task. For the delayed digit recall task (n-back), it consisted of auditory stimuli that the driver would listen to and repeats following the specific rules [13]. The task resembled the non-driving-related task of IVIS. Participants were required to respond to each of the randomly ordered auditory stimuli by repeating out loud the last number presented.

The Surrogate Reference Task (SURT) was used as secondary task. This visual task was done to simulate the usage of non-driving-related task of IVIS. The examples included the operation of controlling of media players and internet browsers. Display of circles would be presented on a screen and participants would use a keypad to choose the section of the screen with the larger circle.

Navigation task also was used for the secondary task. The task was considered as driving-related task of IVIS. An external Global Positioning System (GPS) was secured in the driving simulator. The addresses were provided on a sheet of paper attached to the dashboard. Participants were then asked to input these addresses on the GPS system.

E. Procedure

The procedure of the study is summarized and illustrated in the flow chart in Figure 2. The procedure required approximately one day to be completed by a participant.

Before participants conducted the actual experiment session, they were required to fill in the consent form and personal details. They were briefed about the overview of the experiment, its expected duration, experiment procedure and safety. They were also assessed about their sickness level before driving the simulator.

There were fourteen sub-sessions for the training session, as shown in Figure 2. The training session was required for the participants to familiarize each task before doing the actual experiment session. There was no time limit given. Each training session was stopped when the participants felt comfortable and confidence.

III. EXPECTED RESULTS & DISCUSSION

In this study, the performance measures were calculated in term of response time. The response time (RT) is defined as the time from stimulus inception until the response from the micro-switch is recorded.

In theory, the anticipated results are reaction time, which is supposed to be fastest when drivers are performing an easy task during simple road conditions. Response time should be slowest when drivers are performing the hardest task on the complex road. Further analysis using Analysis of Variance (ANOVA) technique could be used to compare the means of three categories of road types (highway, ramp and curvy) and secondary tasks (n-back, SURT and navigation task).

The challenges faced were difficulties in finding suitable participants that have a high commitment. This study took a long time (approximately 9.00 a.m. to 5.00 p.m.), hence
becoming the major cause of problems in finding the participant. Besides that, some participants felt simulator sickness. The sickness happened when they were exposed to a virtual environment, where effects of technology parameters such as visual projection quality and condition were not favourable. It could also be due to individual factor such as gender and age.

IV. CONCLUSION

In summary, the development of the simulator for IVIS evaluation has been fulfilled. Nevertheless, the evaluation of the IVIS is still on-going. As this study involved simulated traffic experiment using driving simulator, we found that it was very practical as compared to real road study using instrumented car due to less risk, under controlled environment to perform the experiment and consuming less cost.

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REFERENCES