Effect of VR Device – HMD and Screen Display – on the sickness for Driving Simulation

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Keywords: *Driving simulation, simulation sickness, motion sickness, head movements, virtual reality.*

Introduction

In this article, an experimental procedure is presented in order to evaluate HMD oculus and medium range field of view ECO_2 static simulator according to driving simulation sickness. The driving simulation sickness is investigated with respect to SSQ (simulator sickness questionnaire) and vestibular dynamics (head movements) of the driver participants for a specific driving scenario. The scenario of driving task is created by using open source "iiVR (institut image virtual reality)" software which is developed by Institut Image Arts et Métiers ParisTech. The experiments are executed in static mode for driving simulator.

Methods and Materials

The driving simulators are getting more and more deployed to evaluate the vehicle dynamics, advanced vehicle control systems such as ESP (electronic stability program), ABS (anti-block braking system), ACC (adaptive cruise control), LAC (load adaptive control) etc.… powertrain systems (such as gasoline, diesel internal combustion engine, hybrid or electric vehicles), ADAS (advanced driver assistance systems) and autonomous driving for the first prototypes of the new developed cars. Not only the vehicle concepts but also the driver behavior play crucial role in the development process. In general, there are two different types of driving simulators as [Ayk14; Ayk13]:

- static driving simulators (without motion platform)
- dynamic driving simulators (with motion platform)

A computer automatic virtual environment (CAVE) system is a multi-sided box with displays for each wall used to immerse a user in a virtual environment. It has been widely used for virtual immersion as the head-mounted displays (HMDs) were not mature VR technology [Man04 ; Sh06 ; Tos04]. However, current HMDs are now able to compete with many CAVEs and actually have started to take over them [Hav11]. Several studies used such visualization systems (HMD or CAVE) and the evaluation is done through an adapted Slater et al. questionnaire [Sla94 ; Jua09]. A study has been made in order to compare the levels of presence and anxiety in an acrophobic environment that is visualized by using a CAVE and a head-mounted display (HMD) [Jua09]. In that environment, the floor was falling away and the walls were rising up. According to [Jua09], the CAVE induces a more elevated level of presence in users. The anxiety stage was also examined at different times during the experiments. The results emphasize that both visualization systems provoke anxiety, however that the CAVE provokes anxiety more than the HMD does. The animation in which the floor has fallen away is the most important reason that has caused a higher provocation of the anxiety. [Jua09]. The research question addressed by our study is related to the effect of VR device (larger screen versus HMD) on the motion sickness in driving simulation condition. In our study, the effect of field of vision has been discussed by using Oculus Rift HMD and ECO_2. The aim of the experiments is to differentiate the influence of having HMD oculus and medium field of view static driving simulator (ECO_2) for the driving simulation aspect and to compare the convergence to the reality for each condition. Hence, a scenario has been created that enables generating a specific driving incidence. The scenario is composed of several roundabouts and curvatures as well as in presence of traffic and pedestrians.

Figure 1.a illustrates the Playseat low cost static driving simulator with use of HMD Oculus, whereas Figure 1.b indicates a real-time driving experiment in the ECO_2 driving simulator. Experiments have been realized with the participation of 14 subjects in Institut Image Arts et Métiers ParisTech. For each type of VR device (HMD and ECO_2), the vestibular dynamics related motion sickness (objective

metrics, Figure 3) and the psychophysical situations (subjective measures through questionnaires, Figure 2) of the drivers' have been measured.

Figure 1 : a. Oculus rift HMD (upper view) b. ECO_2 in driving simulation (bottom view)

Results and Discussion

We conclude that presence in VR has less effect on reducing the sickness whereas the FOV has a higher influence on decreasing the level of sickness. Also due to the Pearson's correlation results for the head-vehicle interactions with respect to pitch and roll velocities, the r-values are positive for the ECO_2 condition while r-values for the Oculus HMD condition are negative. Positive r-value shows an objective metric for the avoidance of visual-vestibular conflict. These results show that the both VR systems bring the same virtual immersion (sense of presence). But, the HMD induces most sickness compared to the ECO_2. Because the HMD system is more immersive and tends to isolate the subject from a real visual marking, application containing important navigation (as for driving simulation condition) may provoke much more easily sickness than other VR system.

Table 1: Subjective comparison of VR device

	Oculus HMD	ECO_2
Field of View (FOV)	-	+
Presence in VR	+	-
Sickness	-	++

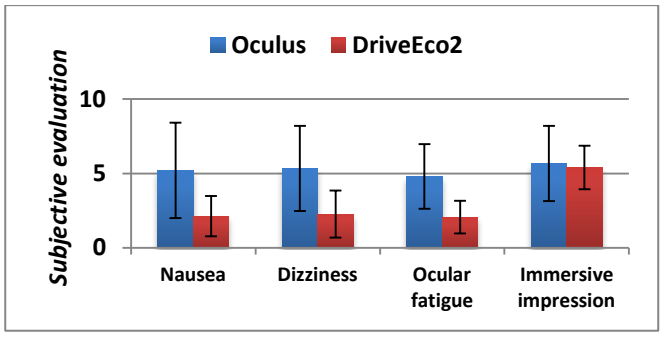

Figure 2: Subjective evaluation

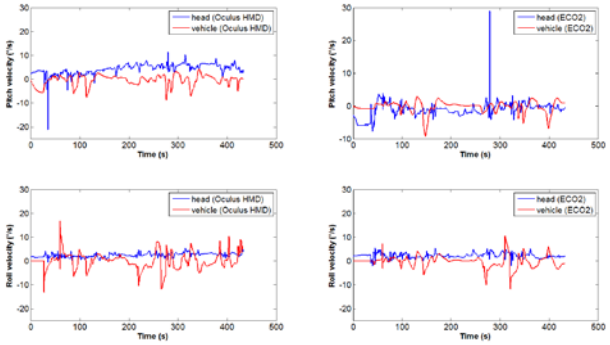

Figure 3: Objective evaluation

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