Impact of Immersion and Realism in Driving Simulator Studies

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ABSTRACT

Driving simulators emerged as a promising technology for the analysis of driving conditions and road users’ behaviour in an attempt to tackle the problem of road accidents. The work presented herein demonstrates the design and development of a driving simulator that aims to contribute towards evaluating black spots in road networks by promoting rapid design of realistic models and facilitating the specification of test scenarios. A reliable driving simulator should be able to reproduce the driver’s behaviour in a realistic way. In this study the authors examine different setups of the simulator to define the one that achieves highest levels of reliability. The chosen setup is then used to evaluate the impact of distractors (e.g. billboards) on driving behaviour of local road users for a chosen black spot in Limassol, Cyprus. Data collected from the experiments are analysed, and the main findings are presented and discussed.

Keywords: Computer Graphics, Driver’s Behaviour, Driver’s Distraction, Driving Simulator, Immersion, Realism, Virtual Reality

INTRODUCTION

3D Simulators have been widely used in several disciplines including transportation. They are used for various reasons, such as visualizations, training, testing conditions, etc. One of the main purposes of simulators, in transportation discipline, is for training and education. Such simulators (e.g. flight simulators) are used to train participants under difficult circumstances with no risk for participants or others’ safety. Moreover simulators in transportation can be exploited for road safety, for example to
examine different parameters that may affect drivers’ performance.

Finding ways to reduce road accidents is a must. Facts show that they have become a daily hazard in Europe and worldwide (Konstantopoulos et al., 2010). According to Eksler et al. (2008), around 1.2 million fatalities and more than 50 million injuries occur in roads worldwide every year. Given the current trends, the accident fatalities are projected to become the second most common cause of death in 2020 if no drastic measures are taken. To that end, EU set the goal to reduce road fatalities and injuries by 50% by 2020. In addition to fatalities, traffic accidents result in high economic losses due to traffic congestion which in turn leads to a wide variety of adverse consequences such as traffic delays, supply chain interruptions, travel time unreliability, increased noise pollution, as well as deterioration of air quality.

The use of a driving simulator in studies aiming to reduce accident occurrences is inevitable, firstly due to ethical reasons and secondly, since controlling infrastructural parameters in the real world requires huge investment of time and money (Davenne et al., 2012) which is usually prohibitive. Driving simulators provide the researcher with a powerful tool to test driving behaviour under controlled settings.

The contribution of this work is three fold:

1. Design and development of a 3D driving simulator: the method proposed herein demonstrates the design of a driving simulator that exploits 3D modelling tools in a module-based approach to promote realism and interactive 3D representation of road networks. The approach simplifies the process of implementing 3D road infrastructure models through the utilization of reusable modules. This simplifies the process of designing/modifyng the simulation model by reusing model constructs in a plug and play fashion. This enables the analyst to easily design a range of experimental conditions to evaluate assumptions and hypotheses from different perspectives.

2. Testing different setups of the simulator, related to computer graphics and virtual reality aspects, affecting its reliability: a key factor in an efficient simulator is to simulate in a realistic way, not only the 3D virtual environment (static or dynamic) that surrounds the participant, but be able to reproduce the participant’s reactions in the same way as if the participant faces the same scenario in real life. In computer games and virtual environments it is generally accepted that integration of advanced illumination algorithms for the 3D geometry of the environment helps towards the increase of realism of the scene. Moreover, using virtual reality devices, such as Head Mounted Displays (HMD), increases the immersion of the user. An HMD device is mounted on the user’s head and allows stereo display through the two screens, in front of user’s eyes (Figure 1). HMDs allow high degree of immersion, since the user only sees the virtual environment without intrusions from the real world. Moreover, it has an integrated head tracker enabling the automatic update of the scene’s virtual camera based on the orientation of user’s head. Display device and illumination were the conditions tested in this study in regards to the validity of the simulator.

3. Testing environment’s infrastructure parameters affecting driver’s performance: in particular, this investigation focuses on the impact of different types of driver distractions, such as advertisements, on the primary task of driving. The advertisements billboards are placed along a critical point of a road network in Limassol, Cyprus. Two types of traffic control (i.e. with and without traffic lights) are also examined under dangerous traffic conditions.

The article is organized as follows: related work is firstly reviewed, followed by the presentation of the driving simulator design. Description of the experimental designs for both parts of the study follows and the paper concludes with the analysis of the results and a discussion of their implications.
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