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Design and development of driving simulator scenarios for road validation studies

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Abstract

In recent years, the number of road-based studies using driving simulators is growing significantly. This allows evaluating controlled situations that otherwise would require disproportionate observations in time and/or cost. The Institute of Design and Manufacturing (IDF) of the Polytechnic University of Valencia (UPV) has developed, in collaboration with the Engineering Research Group Highway (GIIC) of the UPV, a low cost simulator that allows rapid implementation and effectively a new methodology for validation studies of different roads through the implementation in the simulator scenarios of existing roads. This methodology allows the development of new scenarios based on the analysis of a layers-file system. Each layer includes different information from the road, such as mapping, geometry, signaling, aerial photos, etc. The creation of the simulated scenario is very fast based on the geometric design software, making it easier to consulting firms using the system that can evaluate and audit a particular route, obtaining reliable conclusions at minimal cost, even if the road is not actually built. This paper describes the basic structure of the layers generated for developing scenarios and guidelines for the implementation thereof. Finally the application of this methodology to a case of success will be described.

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1. Introduction

Simulation can be described as a method of reproducing a situation similar to reality, yet controllable. To be achieved, it is necessary to reproduce an environment with identical stimuli to a real situation. This feature converts a simulator into a flexible scientific research tool – assisting laboratory experiments that could be expensive, dangerous, or unrepeatable in the real world. In the field of driving, simulations are performed with *driving simulators*. These devices generate situations requiring the same responses as real-life driving – but without the risks of being on the road. The basis for assessing any simulator is applicability. Simulators must be designed and equipped according to their intended use. Driving simulators have been developed enormously over the past years. Actually exist versions ranging from PC-based models to high-level models such as the *Daimler-Benz* (Nordmark, 1990; Weir and Clark, 1995). By using driving simulators, a wide variety of studies can be undertaken regarding: the driver; the vehicle; and the road.

Sometimes it is useful to categorize driving simulator research according to experimental variables instead of study objectives. These variables are in accordance: the driver; the vehicle; the environment; and the road. Examples of these types of studies can be seen in Table 1. Basically, the advantages of using simulators as a research tool can be summarized as: experimental works can be closely defined and easily repeated, parameters and experimental variables can be both easily modified and stored, the effects of driver fatigue can be safely studied, accidental or unpredictable situation can be analyzed safely, and prototypes and series design decisions can be made at an earlier phase of development.

Table 1. Type of studies undertaken with simulators depending on selected variables.

DRIVER RELATED STUDIES	VEHICLE RELATED STUDIES	ROAD & ENVIRONMENT
Drugs, age, fatigue, effects of medical treatment, mental and emotional states, alertness, personality aspects, mental and physical disabilities, other medical conditions, risk-taking mentality, training, warnings, information, etc.	Vehicle type, dynamic qualities, control response, information mechanisms (form, content and location), field of exterior vision, restraint systems, interior environmental factors, passengers, ADAS, V2X, etc.	Road geometry, road markings, surface properties, road structure elements, visual texture, color, indications, vehicle speed, traffic regulators, lighting, weather, pedestrian and other vehicles, obstacles, off-road handling, etc.

In accordance with more modern thinking, the driving simulation is regarded as a tool for promoting risk awareness and a way of allowing the driver candidate to try out various driving situations which cannot be planned in regular traffic or which would involve excessive danger on the road (Verwey, 1995). However, the purpose of the simulator in many human factors studies is to detect differences in performance produced by changes in the subject's capabilities (e.g. under the influence of alcohol or reduced capabilities due to illness or disability) or differences in secondary-task loading (e.g. use of an in-vehicle route-guidance system) (Read and Green, 1999).

A simulator with a good fidelity should be able to train the basic psychomotor aspects (control of the steering and speed) under complex conditions. Even more important, a simulator with a good control in the scenarios can teach a wide range of cognitive abilities that are required to deal with complex roads and conditions of difficult traffic, including appropriate situation awareness, hazard perception, decision taking and defensive techniques of driving (Allen et al. 2000).

The use of driving simulators in studies of road design, mainly to analyse the influence of geometry in driver behaviour has been widely performed by different researchers, both affecting the coordination of the horizontal layout and elevation, cross section analysis, overtaking manoeuvres, access to acceleration and deceleration lanes, intersection design and signalling. In addition, driving simulators constitutes a very useful tool to study road safety taking into account the human factors, as they may be able to generate virtual scenarios where the driver can act similarly as it would do in a real road. The road to analyse may have already been built or being under design, to be evaluated from a safety perspectives. In this case, driving simulators can introduce a better analysis due to research developed would allow to obtain data at a lower cost, lesser risk and greater control over the variables under study, mainly speed.

The analysis of a virtual road that only exists in the early design phase in a driving simulator, it provides an accurate

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