Usability Heuristics and Design Recommendations for Driving Simulators

Aníbal Campos, Cristian Rusu, Silvana Roncagliolo, Fabiola Sanz, Raúl Gálvez and Daniela Quiñones

Abstract User eXperience (UX) is one of the most important aspects when developing a simulator. It ensures that the final product is not just functional, but users find a value in what they are getting. The paper presents a set of heuristic to assess usability in driving simulators. It also defines a set of design recommendations focused on UX.

Keywords Driving simulator · User experience · Usability · Usability heuristics · Design recommendations

1 Introduction

Driving simulators are objects of learning that attempt to model part of a reply of the reality phenomena. They are interactive environments, which allow users to modify parameters and to see how the system reacts. Simulators are used in many disciplines.

The ISO standard 9241-11 defines usability as "the degree to which a product can be used by specific users to accomplish certain specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [1]. The ISO 9241-210 standard defines User eXperience (UX) as the result of the perceptions and answers of a person for the use and early use of a product, system or service [2]. UX extends the usability concept. The heuristic evaluation is probably the most widely used usability inspection method [3].

The paper presents a set of usability heuristics for driving simulators and a set of design recommendations. Section 2 presents the proposed heuristics. Section 3 briefly references the UX – oriented design recommendations. Finally, Section 4 presents the conclusions and future work.

A. Campos · C. Rusu · S. Roncagliolo · F. Sanz · R. Gálvez · D. Quiñones(✉)
Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile
e-mail: anibal.campos.baez@gmail.com, faby.sanz.b@gmail.com,
raul.galvez.cabeza@gmail.com, danielacqo@gmail.com, {cristian.rusu,silvana}@ucv.cl

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2 A Set of Usability Heuristics for Driving Simulators

The set of usability heuristics for driving simulators (HS) was developed based on iterative methodology [4]. Three iterations have been done. The set of heuristic is presented below. Heuristics are presented in an abbreviated form: (ID), Name and Definition.

(HS1) *Virtual environment*: The driving simulator should have a virtual environment that provides the user the possibility to drive in several real-life situations.
(HS2) *Visibility of the vehicle*: The driving simulator should give the user control over the vehicle components and enable set the visual effects.
(HS3) *Consistency and standard*: The driving simulator must be consistent in the use of language and visual elements used in accordance with reality.
(HS4) *Cabin of control*: The driving simulator must have a dashboard of the vehicle easy to understand by the user.
(HS5) *Simplicity*: The driving simulator must not overload the user with information.
(HS6) *Challenges and rewards*: The driving simulator must explain which is the purpose or goal of the given lessons.
(HS7) *Level of difficulty*: The simulator must have different levels of difficulty, allowing implement several real-life situations.
(HS8) *User memory load*: The user should not have to remember information of a part of dialog one part to another.
(HS9) *Camera control*: The user must be able to see the vehicle from different angles, allowing the user to select the desired view.
(HS10) *Vehicle control*: The driving simulator must offer the option to use diverse controls that allow the user to interact with the virtual environment, as well as select the type of vehicle transmission.
(HS11) *User control and freedom*: The driving simulator must provide emergency exits, undo and redo.
(HS12) *Flexibility and efficiency of use*: The driving simulator adapts to different work styles and also lets the user customize the type of vehicle.
(HS13) *Learning and continuity*: The driving simulator provides lessons in line with current traffic regulations and records the results.
(HS14) *Prevention of errors*: The driving simulator must prevent the user commits critical errors that may cause an infraction.
(HS15) *Error Recovery*: The driving simulator must clearly indicate to the user how to recover of a mistake.
(HS16) *Help and Documentation*: The driving simulator should provide help information, easy to find for the user.

The development of the HS usability heuristics was based on three case studies: *SimuDrive*, *City Car Driving*, and *DriverTest*. Several experiments were performed.

The refined set of HS heuristics was compared against Nielsen's usability heuristics [5]. Three experts evaluated *DriverTest* using HS heuristics (experimental group); a total of 50 usability issues were identified. Other three experts evaluated *DriverTest* using Nielsen's heuristics (control group); a total of 25 usability issues were identified. The HS heuristics allowed finding additional problems that were not considered when using Nielsen's heuristics, associated with the specific characteristics of the driving simulators, and directly related to the learning process.

3 Design Recommendations for Driving Simulators

Some basic features that a driving simulator should have are described by Navarrete et al. [6]. Based on these features, the Peter Morville's UX model [7], and the set of usability heuristics previously defined, the following design recommendations were proposed. They are presented in an abbreviated form: (ID) and Name.

(RS01) *Learning rules of the road*. (RS02) *Real challenges*. (RS03) *Virtual environment*. (RS04) *Exit Control*. (RS05) *Flexibility of use*. (RS06) *Easy to remember*. (RS07) *Vehicle control*. (RS08) *Vehicle status*. (RS09) *View Control*. (RS10) *Control cabin element*. (RS11) *Consistent language*. (RS12) *Simplicity*. (RS13) *Control of difficulty*. (RS14) *Error prevention*. (RS15) *Error recovery*. (RS16) *User Help*.

4 Conclusions

A set of usability heuristics for driving simulators was developed and validated through three case studies, and based on expert evaluators' feedback. Experimental validation shows that the heuristics we proposed provides better results than generic usability heuristics. We also proposed a set of UX – oriented design recommendations for driving simulators.

As future work, we intend to validate the design recommendations through the implementation of functional prototypes, which will then be tested through usability inspections and UX testing.

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