Interface Design Patterns for In-Vehicle Infotainment Systems

Subjects: Computer Science, Interdisciplinary Applications
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An in-vehicle infotainment system, or IVIS, corresponds to the set of components used to provide information and entertainment to the driver and other passengers in the vehicle, through interfaces supported with audio and video, control elements such as touch screens, central panels with buttons, voice commands, among others. These kind of IVISs bring with them a world full of interaction opportunities for both the driver and other passengers to complete driving-related tasks and other secondary activities mostly related to entertainment that complement the in-vehicle experience. However, the increase in the number of components provided by this type of system, and even the design under which these elements are distributed, can cause the user–vehicle interaction to increase the complexity of the experience, and therefore, it could make it difficult to carry out secondary tasks and, in a worse scenario, affect safety while driving.

Keywords: infotainment systems ; design patterns ; user interface

1. Introduction

Today, the automotive industry has been positioned as one of the most important economic sectors in the world [1]. In recent years, globalization, digitization, and the constant growth of competition have caused this industry to face a great number of challenges and changes [2]. These new challenges lead the different companies to make decisions in the design, development, manufacturing, and other processes, to improve the experience of drivers and passengers. New technologies such as autonomous vehicles, the Internet of Things (IoT), facial recognition, gesture detection, modern infotainment systems, among others, immerse users in a world full of opportunities for interaction and bring with them an incalculable number of additional activities to the portfolio of tasks compared to previous years [3]. One of the technological trajectories that has managed to emerge in conjunction with the growth of the automotive industry is the incorporation of infotainment systems in vehicles [4].

In fact, according to [5], it has been proven that the improper use of advanced infotainment systems such as Android Auto™ or Apple CarPlay® while driving can be more dangerous than driving under the influence of alcohol or cannabis, which supports the hypothesis of the researchers of the referenced work, who argue that current approaches that guide the design of infotainment systems are not sufficient to achieve the levels necessary for safe driving. Performing a secondary task demands a high level of cognitive attention; likewise, it is possible that it requires high levels of visual or physical attention, which can lead the drivers to divert their eyes from the road, their hands from the wheel and, in general, leads them to remain in a state of constant distraction [6]. These are some of the reasons why it is important to prioritize the safety of the driver and passengers when designing the infotainment system, because, although greater permissiveness is being provided and a better user experience may be being sold, the results of driver–vehicle interaction can lead to unwanted events.

Some European [7], Japanese [8] and American [9] organizations, involved in the automotive industry, have proposed some guidelines for the design, placement, and distribution of infotainment system components inside the vehicle, ensuring that the general design of the system is more focused on the welfare of the driver and passengers, as well as in search of a better relationship between interface and user [10][11]. While this is a positive step, these design guidelines are not required for vehicle development, and compliance with their recommendations is voluntary. In addition to this, and although some of the guidelines try to give a global vision of the factors to take into account for the implementation of infotainment systems in the vehicle, they are designed under the context of each of the regions in which the proposal was made, omitting difficulties and behaviors of users belonging to different socioeconomic groups, different levels of education and without a doubt, with another mental model, as drivers from Latin American countries may have. Users' preferences in interface design are very important and are given great attention by technology designers and application developers. One of the main features of the design approach is the cultural feature.

2. User Interface Design Patterns for Infotainment Systems Based on Driver Distraction

During the last decades, international government entities and automotive original equipment manufacturers have published different guidelines and design principles that seek to facilitate interaction with vehicle infotainment systems and specify certain characteristics of automotive human–machine interfaces to ensure both good user experience and adequate road safety. The most recognized publications have been developed by the European Commission (EC) [12], the Japan Automobile Manufacturers Association (JAMA) [13], the Alliance of Automobile Manufacturers (AAM) [14] and the National Highway Traffic Safety Administration (NHTSA) [15].

The EC has issued a series of design recommendations condensed in the document of the European Statement of Principles on HMI, commonly referred to as ESoP [7]. The ESoP, last updated in 2013, includes safety aspects that must be considered for the design of human–machine interfaces (HMI) of in-vehicle infotainment systems, and is made up of three general design principles on the human–machine interaction and 32 principles that cover the areas of system installation, information presentation, interaction with screens and controls, system behavior and information about the system.

The Design Guidelines for Display Systems in Vehicles [8], in its third version published by JAMA in 2004, brings together 4 basic principles and 25 specific requirements for the design of the interfaces of display systems in vehicles to guarantee the user the safe use of the different functionalities while driving. The main areas in which the requirements are grouped include the installation of the system, the functions of the system, the operation of the system while the vehicle is in motion, and the presentation of information to users.

The Statement of Principles, Criteria and Verification Procedures on Driver Interactions with Advanced In-Vehicle Information and Communication Systems [16], developed by the American AAM (2006), sets out 24 design principles grouped into 5 sections: principles of installation, principles of presentation of the information, principles on interactions with screens/controls, principles of the behavior of the system and principles of information about the system.

Among the many NHTSA publications related to the design of infotainment system interfaces, the Guidelines to Reduce Visual–Manual Driver Distraction During Interactions with Electronic Devices Integrated in the Vehicle (2013) stand out for the work [17], corresponding to Phase I of the guidelines related to driver distraction. This first phase applies to the electronic devices of the vehicle used by the driver to perform secondary tasks (communications, entertainment, navigation and so on) through visual and/or manual means. The document lists certain ancillary tasks that the agency identifies as inherently interfering with the driver's ability to safely control the vehicle and specifies a test method to measure "eye glance behavior" during the performance of these tasks. Phase II of the guidelines (2016) [18] addresses the visual–manual distraction produced by interaction with portable and aftermarket devices, and Phase III (still under construction) will address the driver distraction produced by auditory-based interfaces in voice interaction [19].

On the other hand, in the literature search of existing design patterns, a set of design patterns applied to the automotive domain and with a focus on the user experience within the vehicle was found. This proposal is described in [20], where a group of researchers from the human–computer interaction (HCI) area work together with engineers and designers from the automotive industry to present a set of eight UX design patterns in the vehicle that offer solutions to recurring problems in the design of human–vehicle interactions. The problems faced in these patterns include the depth of the menu and number of options in the interfaces of the systems, the size of the touch field of the screen, the design of warnings and auditory information, the choice of the best modality for the visualization of warnings, the response time of the system when interacting by touch mode, the size of the icons presented on the screen, the choice of suitable colors for on-screen display, and the preference for using touch screens or physical buttons.

It was showed that the existence of various principles, guidelines and recommendations for the design of user interfaces of infotainment systems in vehicles; however, no publications of this type were found in the Latin American context. There are some publications where cultural aspects have been considered in the design of website applications [21]. The regional mental model is paramount in human–computer interaction area, especially in user-centered design, which focuses on having an explicit understanding of the user's needs, the tasks to be performed, and the characteristics of the environment and context in which the system will be used, in addition to involving the user during the design and development process [22]. This explicit understanding of the user, their requirements and their environment, helps designers to have a better understanding of their mental model, and the smaller the gap between the designer's mental model and the user's mental model, the probabilities of having a positive user experience will be greater, because errors can be prevented and the user's navigation through the system occurs in a more intuitive way [23].

This is a special form of “Mental Models”, a term strongly associated with [24] the so-called “Situation Models”, as per [25]. Ideally, one would like to also have the UX device itself have a situation model of different aspects of the human being, their environment, and the tasks at hand for the human, in order to adapt its behavior and, thus, try to reduce some dangers; certainly, part of the future research will go toward that direction, toward pro-active interfaces that understand the situation and the user’s current tasks and intentions. In that way, the so-called “Grounded Situation Model” [26] theory and techniques will be of primary importance to be considered in further works. For that reason, it is too relevant to consider cultural aspects into the design of any kind of interactive systems (and in particular in the infotainment systems design) [27].

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