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Product interface design: A participatory approach based on virtual reality

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Abstract

The usability of the user interface is a key aspect for the success of several industrial products. This assumption has led to the introduction of numerous design methodologies addressed to evaluate the user-friendliness of industrial products. Most of these methodologies follow the participatory design approach to involve the user in the design process. Virtual Reality is a valid tool to support Participatory Design, because it facilitates the collaboration among designers and users.

The present study aims to evaluate the feasibility and the efficacy of an innovative Participatory Design approach where Virtual Reality plays a 'double role': a tool to evaluate the usability of the virtual product interface, and a communication channel that allows users to be directly involved in the design process as co-designers.

In order to achieve these goals, we conducted three experiments: the purpose of the first experiment is to determine the influence of the virtual interface on the usability evaluation by comparing "user–real product" interaction and "user–virtual product" interaction. Subsequently, we tested the effectiveness of our approach with two experiments involving users (directly or through their participation in a focus group) in the redesign of a product user interface. The experiments were conducted with two typologies of consumer appliances: a microwave oven and a washing machine.

Keywords: Participatory design; Virtual reality; Usability; Product interface design

1. Introduction

The design of the interface is a critical task in the product development process, because it directly influences the customers' satisfaction and, consequently, the success of the product on the market. One of the most important characteristic of a user interface is usability: as stated by the ISO 9241 norm part 11 (ISO/DIS 9241-11), usability is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use".

Recent research (Muller and Kuhn, 1993; Schuler and Namioka, 1993; Reich et al., 1996; Finn and Blomberg, 1998; Demirbileka and Demirkan, 2004) has described the Participatory Design (PD) as an emerging approach that considers users as the core of design processes and aims to guarantee usability, simplicity and intelligibility of the product. The peculiarity of such a method is due to the direct involvement of end users during all phases of the product development; the user actively takes part in the whole project procedure, and his contribution has a fundamental significance in the product characterisation because he/she drives the assessment of any design variables.

The effectiveness of the PD approach in the product design is well documented in literature (Schuler and Namioka, 1993; Finn and Blomberg, 1998; Kujala, 2003), but there are also apparent limits of the current approaches that we have tried to tackle through the introduction of specific technologies and tools:

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- The designers' proposals have to be presented as expensive prototypes, because many users cannot understand theoretical concepts and prefer discussing existing products or realistic mock-ups (Kima et al., 2004; Nevalaa and Tamminen-Peter, 2004; Olsson and Jansson, 2005; Sharma et al., 2008). A physical mock-up of the product concept can be realised only in the final stages of the development process, causing a delay in discovering design problems.
- The designers and the users do not share a common language and have different cultural backgrounds, thus complicating communication and cooperation in the design activities. Generally, designers collect suggestions and ideas from the users through questionnaires and interviews (http://www.usabilitynet.org/trump/methods/methodslist.htm) but these methods are inadequate to implement a real PD approach (Carmel, 1993; Bruseberga and McDonagh-Philp, 2002; Isomursua et al., 2004; Dinka and Lundberg, 2006; Luck, 2007).

In other words PD suffers from a lack of tools that are able to quickly transmit the designers' intent to the users giving back suggestions, ideas, and a performance evaluation. In our opinion, Virtual Reality (VR) may be used to develop specific tools that are able to solve these problems because in a Virtual Environment (VE) it is possible to design, simulate, analyse and test the digital product in a very user-friendly way. Thanks to its peculiar characteristics (real time interaction, more intuitive input devices and stereoscopic visualisation), VR appears to be a highly appropriate medium for the involvement of users during the design activities. We consider VR systems the tools that, more than others, have the right requirements for a PD approach because:

1. Virtual Prototypes may replace the physical mock-ups with a notable reduction of costs and "time-to-market".
2. Virtual Reality may be considered as a "*communication channel*" (Reich et al., 1996) among designers and users. Thanks to VR, communication becomes a continuous process of perspective, conceptualisation, and information exchange, always requiring interpretation and translation of both the designers and users who are learning, building and evolving shared meanings of design situations.

The use of VR in PD has been tested in several application fields like road planning, medicine, and work place layout (Davis, 2004; Dinka and Lundberg, 2006; Finn and Blomberg, 1998; Heldal, 2007; Mobach, 2008; Mogensen and Shapiro, 1998; Reich et al., 1996; Schuler and Namioka, 1993) but it has scarcely been tested for industrial product design and, in particular, there are no studies on usability tests of the product interface in VE.

In order to verify these considerations, we have developed a system named VP4PaD (Virtual Prototyping for Participatory Design) (Bruno et al., 2006, 2007) that aims to favour the user/designer collaboration, through the direct interaction with a 3D model of the product interface; this system helps to overcome the existing limits of PD approaches which use drawings, notes or interviews. VP4PaD allow the users to sketch the product interface selecting the functional elements (Human Interface Elements (HIEs) (Han et al., 2002)), such as buttons, handles, switches, etc.) that they prefer, and to place them in the desired layout. With this tool the user creates a virtual prototype that is fully operational in order to reproduce (in the VE) the behaviour of the product interface. These virtual prototypes are employed to rapidly perform the usability test reducing time and costs of the evaluation and having the possibility to involve end users of a product from the earliest stages of the design process without the need of a physical mock-up and with the advantage of being able to assess several design options in VE.

The main contribution of this paper is to determine the effectiveness of VP4PaD for the involvement of final users in usability analyses and PD sessions. This evaluation has been done through three studies that analyse three different issues:

1. The main issue is that VE may invalidate the usability tests done with the virtual product. In fact, it is apparent that the interaction with a virtual product is not as easy as the interaction with a real product, because the VR devices may create an additional difficulty for the user that have to complete the test. To give an answer to this question we have conducted a study, reported in Section 4, that compares the "user–real product" interaction and "user–virtual product" interaction, in order to determine the influence of the virtual interface on the usability evaluation done through a digital mock-up.
2. Since the direct use of VR tools may not be acceptable by the end users, we try to adapt VP4PaD to conduct focus groups analyses where an operator interacts with the virtual prototype, while the end users are asked to give a feedback about the product interface. A second study, reported in Section 5, evaluates the efficacy of this approach comparing the usability of the interface of a commercial microwave oven with a new one redesigned by taking into account the data collected from a focus group analysis done with VP4PaD.
3. Finally, we have evaluated how VP4PaD may support the direct involvement of the end users as co-designers, giving them the possibility to sketch the product interface and immediately test its functionalities. The study, reported in Section 6, evaluates if this approach may improve the product interface and may facilitate the involvement of end users in the initial design phases.

The usability tests, realised in these three studies, refer to the ISO 9241 norm, part 11, that defines the elements which have to be detected through empirical usability tests: efficiency (time required to carry out a task), effectiveness