Sustainable Practices in Electronics Engineering: Inclusion of Virtual Reality in Product Testing

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Abstract— **Virtual reality (VR) technologies provide novel and enhanced modes for human-computer interaction that can be used as a potential tool to provide product user experience and usability evaluation which are more efficient, even in the early stages of the product design. This paper presents a conceptual approach to virtual reality technologies application in the evaluation of usability in consumer product design.**

Resumen— **Las tecnologías de realidad virtual (VR) brindan modos novedosos y mejorados para la interacción humano-computadora que se pueden utilizar como una herramienta potencial para proporcionar una experiencia de usuario del producto y una evaluación de la usabilidad que son más eficientes, incluso en las primeras etapas del diseño del producto. Este trabajo presenta una aproximación conceptual a la aplicación de tecnologías de realidad virtual en la evaluación de la usabilidad en el diseño de productos de consumo.**

I. Introduction

The product testing process in the electronics engineering industry entails a number of constrains. Among these, four main issues can be mentioned, namely, high cost, great number of resources, high amount of time and general security issues. It is of great importance to develop and implement new methods to improve efficiency and strengthen security in this field. In this sense, the improvement and advancement of Virtual Reality (VR) may help fulfill this aim, as the National Academy of Engineering (NAE) suggests. The need to "enhance virtual reality" [1, p.42] poses a challenge for engineers to develop technologies to test products in a sustainable way.

The purpose of this paper is to discuss the application of virtual reality in the product testing process in the electronics engineering industry. In order to achieve this aim, this paper is organized as follow. First, the product testing process in effect will be described. Second, the inclusion of VR in the product testing process will be discussed. Finally, the advantages and disadvantages of the VR uses in the electronic industry will be analysed.

II. Product Testing in Electronic Engineering

In today's electronics field, the importance of testing products is undeniable. In fact, more time is required for testing than for the design and manufacturing of products. When a circuit or device is developed, it is necessary to determine their functional and timing specifications.

When multiple copies of a circuit are manufactured, it is essential to test a prototype first and then each copy to verify whether the manufacturing process has introduced any flaws. In order to meet the requirements of the consumer, it is essential to test the circuit effectively before it is released into the market.

Good testing has numerous advantages. It leads to better quality products, good brand value for companies and high customer satisfaction. As well as this, it improves yield in manufacturing.

Companies adopt prototypes in these usability testing, in order to identify problems and to seek correction in an agile way and lower costs. This reduces the risks of a negative perception of usability when the product is already in the market [2]. Despite the benefits provided by the use of physical prototypes, in most cases, their manufacturing is expensive and requires a certain amount of time. Additionally, once ready, they usually require reworks for updates from design changes [3].

To give an example in the branch of electronics, it is necessary to describe some of the testing principles. During Testing, a set of test stimuli are applied to the inputs of the Circuit/Device under test (CUT/DUT) and the output responses are analysed [3], as illustrated in Fig. 1.

Circuits that produce the correct output responses for all input stimuli are considered as fault-free and the circuits that fail to produce a correct response are assumed to be faulty.

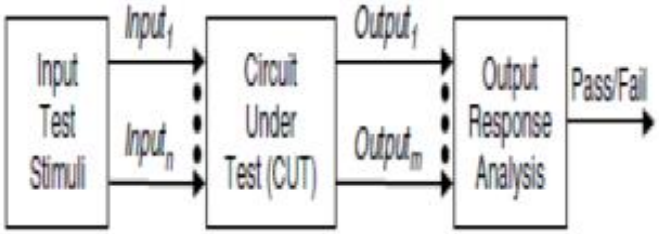

Fig. 1. Basic testing approach [3]

Product testing is important as the product is very expensive to manufacture, generally time consuming, and in some cases physically dangerous to handle. For this reason, it is necessary to include virtual reality in product testing.

III. Inclusion of VR in Product Testing

Depending on the product under development in the design process, several steps must be accomplished in order to ensure that the final product meets the needs of consumers while being successfully accepted by the market [3]. Therefore, the efforts to improve product quality, supported by technological evolution, is a constant feature

in companies [4, p.1]. This improvement can be achieved by means of virtual reality.

The technologies that incorporate Virtual Reality began to be developed in the sixties. However, only the late nineties did they become available for industrial use. By means of multiple peripheral devices, such as motion capture systems and haptic interfaces, VR technologies provide an immersive work environment with different ways of interaction between the user and the system. Virtual reality is a high-quality computer-user interface that involves simulation in real-time and interactions through multiple sensory channels. These sensory modalities are visual, hearing, tactile, smell and taste [5].

In product design, VR can be applied in almost all stages of product development. However, in the prototyping phase, great benefits can be obtained [6]. Prototype, or mock-up involves a scale model, often full size, of a product. It is used for studying, training, testing, and manufacturability analysis. Prototypes can be classified according to the way they are generated:

- *Physical prototypes*.

Traditionally, material is taken from an initial block by means of a variety of processes. The result of the process is a physical prototype in wood, clay, foam or metal although it does not necessarily have the same properties as the finished product.

- *Virtual prototypes (VP)*.

The VP or computational prototype is generally understood to be the construction of product models by computer. This makes its assessment in a simulated functional context easier, without the need to manufacture the product first.[7]

Physical models, which were a common evaluation option in several industries for a long period of time, are expensive and hard to produce. They are nearly invariable so single prototypes have to be produced for every design variation even if only few changes in product data have to be visualized. Consequently, it can bring about negative consequences for the product competitiveness in terms of cost and time to manufacture [8],[9]. By reducing the use of physical prototypes, VR technologies enable cost benefits and agility in the development processes [10].

IV. Advantages and Disadvantages of VR in Prototype Testing

There are numerous advantages of the use of VR in the testing of products, particularly of prototypes. The design and testing using VR technologies are more interactive and easier than using physical objects. This means that more prototypes alternatives can be tested, which would be financially viable [11]. The early representation of future products significantly helps to shorten the time-to-market and thereby to gain competitive advantages. The high complexity of technical products can be simplified by presenting only relevant aspects in virtual models. Thus, virtual prototyping becomes up-to-date concept in design as it reduces the time and cost in product development cycle [12],[13].

In spite of the above-mentioned benefits, sometimes a virtual prototype is less preferable as compared to a physical prototype. Thus, both physical and virtual prototypes have important roles for the design, and advantages and disadvantages in different ways. VR should not be seen as competitive technology, but as complementary one.

Despite having advantages for the development of consumer products, the VR systems are not free from problems and limitations. These are partly caused by: display devices, such as limited field of view and/or low image resolution offered by some HMDs; as well as the interaction devices, such as haptic feedback, involving sensations of weight and shape [6], [14], [15]. It is supposed that the main problem of these limitations is related to the technology quality and stability, because these devices are commercially available with different degrees of technical sophistication.

V. Conclusion

To sum up, the improvement and advancement of Virtual Reality (VR) may help fulfill the aim of the electronics engineering industry of enhancing VR, as the National Academy of Engineering (NAE) suggests. VR in product testing leads to better quality products, good brand value for companies and high customer satisfaction.

A product prototype involves a scale model, often full size, of a product is often expensive and hard to produce. Prototypes encourage product assessment in a simulated functional context, without the need of manufacturing the product first. While physical prototypes are expensive, virtual prototypes are more cost-effective. Additionally, they avoid requiring reworks for updates from design changes that physical models need.

Virtual prototyping becomes an up-to-date concept in design as it reduces the time and cost in product development cycle. The inclusion of VR in product testing may therefore represent a sustainable practice in Electronics Engineering.

therefore, the group has been investigating the efficiency and effectiveness of VR assessment tools based on technological advances, to better support the designer throughout the product development process.

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