Virtual Reality and Eye Tracking in Usability Testing for Industry 4.0

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Abstract. *Virtual reality has emerged as one of the most promising technologies in the context of Industry 4.0. With technological advancements, there is a notable need to modify usability testing in industrial processes to be more practical, safe, and cost-effective, with virtual reality being a key solution. Virtual reality provides a sophisticated solution to these challenges. This work describes the development of a virtual reality based environment to analyse eye-tracking data in the context of industrial usability testing. To this end, tests were conducted using the PICO 4 Enterprise headset, analyzing user attention in a simulated environment created in Unreal Engine.*

1. Introduction

The definition of the term *"virtual reality* (VR)" can be a contradictory term: How can something be virtual and real at the same time? The answer is when there is an existence of a visual interface, where different realities are artificially created but perceived by our sensory system in the same way as the physical world [Tori and da Silva Hounsell 2020], giving the user a feeling of immersion in a different and parallel reality to our world. With this cutting-edge technology, many paths open up for experiments, simulations, and tests with a high degree of realism. Given this, the integration of *VR* within the industry presents a viable opportunity for cost reduction by streamlining usability testing procedures and improving the overall reliability of the product design. With this great potential, the use of this technology goes far beyond a simple observation in the virtual model, thus allowing users to examine the created prototypes in a realistic manner even at the beginning of a product development, so that people without the proper knowledge of the software can perform a complete and highly reliable project review [Wolfartsberger 2019]. For the use of this cutting-edge technology, some software is used for creation, such as Unity and Unreal Engine (UE) in their different versions, being tools primarily used in the development of 3D games on different platforms. With these tools, the possibility of creating simulations for industrial production expands, whether in the production process or in the product itself, also bringing an opportunity to use technologies such as *eye tracking*, which allows studying user vision data, for example, in an automotive panel usability test in a virtual environment bringing greater safety and conducting the tests with greater precision, with the aim of presenting ways to visualize data such as heat-maps, where its free translation would be a heat map, enabling the visualization of studied data from environments and products with greater precision and versatility, unlike in usability test contexts outside virtual reality, which require lengthy and costly processes, as it is necessary to produce the vehicle panel or realistic replicas in the physical world to conduct the tests. In this context, this work describes the development of a *virtual reality* based environment to analyse eye-tracking data in the context of industrial usability testing.

The organization of the remaining parts of this paper is as follows: the materials and methods are described in Section 2; the results are analyzed in Section 3; and the conclusions and future works are described in Section 4.

2. Methodology

We adopted the Design Science Research (DSR) paradigm. In addition to contributing knowledge, DSR contributes to the real-world application environment, as long as the research problem or opportunity has been designed [Gregor and Hevner 2013]. Six project stages should be highlighted: a) study of the tools; b) development of an interactive test environment for data processing and integration of the developed project with virtual reality headsets; c) creation of the scene project with assets; d) software revisions and applications carried out in the research and determining the best software application; e) creation of the final prototyping of the research, applying all the paradigms learned during the process; f) analysis and processing of the collected data for generating analyses with greater precision and dynamics.

3. Preliminary Results

With the development of the project stages, we aimed to create an artifact within the *virtual reality* environment to assess the user's attention level within a vehicular context, divided into 6 stages as previously shown. In the development of the first stage, options for applying *virtual reality* were discussed, where different versions of Unreal Engine 4.27.2 and 5.1 were tested, discussing the strengths and weaknesses of each version and examining the existing functions. Initially, UE 4.27.2 was chosen for the creation of the artifact. After the studies, an initial test environment was created, featuring data manipulation, event activation's, environment manipulation, among other varied tests. Three different environments were created for study, with each researcher involved creating an environment for a global variable, one for data manipulation and local variables, and a final one for environment and user manipulation as shown in Figure 1

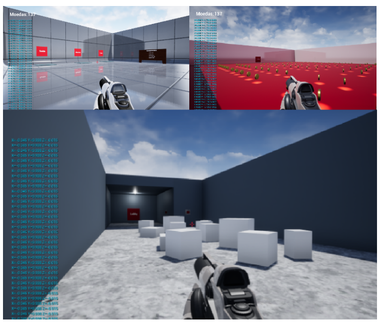

Figure 1. First Test Environment of Unreal Engine

With the learning of the UE tool and the creation of the test environment, the first application was developed using the PICO 4 Enterprise *virtual reality* headset model shown in Figure 2, applying all the knowledge gained in a new environment with testing of the headset's data and *eye tracking* as shown in Figure 3. With the use of the headset, we identified the need to use Android Studio to download the Software Development Kit (SDK) and the Native Development Kit (NDK), which are necessary to send Android application packages to the headset to compile the project.

Figure 2. PICO 4 Enterprise headset used in the research. Source: [Technologies 2024].

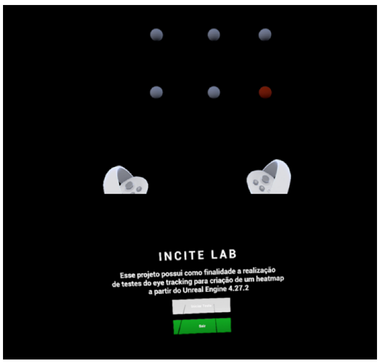

Figure 3. Second Test Environment with PICO 4

After creating a test environment for the headset and *eye tracking*, all applications and learning's were reviewed to determine the UE version for the final prototype, evaluating the main positive and negative points of each version:

Version 4.27.2

- More community support;
- More content and ready-to-use assets;
- Lighter and lower graphic resolution.

Version 5.1

- Larger current user base;
- Fewer ready-to-use contents and assets;

- Heavier and better graphic resolution that does not affect performance on the PICO 4 Enterprise;
- Native functions of the tool for using *eye tracking* and *VR*.

Observing primarily the difference in native functions in UE version 5.1, which already had greater compatibility with *VR* and *eye tracking*, it was decided to use this version due to its greater ease of application and lower need for modification of internal functions. With the final determination of the development tool version as 5.1, a new environment will be configured to implement a heat-map. This heat-map will be generated in real-time during user use, highlighting areas of interest and offering a practical and automated visualization of the data. The goal is to analyze *eye tracking* by collecting information on fixation duration, which ranges from 420 to 690 ms depending on the type of environmental exposure and amount of distractions, and the duration of saccades/microsaccades, which is approximately 12.5 to 13.2 ms [Otero-Millan et al. 2008]. This data will help evaluate the level of ocular fatigue and headaches, providing insights into the user's level of attention and stress. Thus, pointing to a thesis regarding usability tests in VR.

4. Final Considerations

With the development of this work, we can envision the use of *VR* and *eye tracking* for the optimization of processes and products in the industry. The generated artifact aims to enhance the usability of vehicular panels, reducing costs in testing processes and increasing the reliability of final products. Even though the research is not yet complete, it holds significant relevance in the industrial scenario with a solution for testing problems and usability, where what was previously resolved in the real world will be addressed in the virtual one. The next steps in this research are to apply the heatmap in VR and integrate it into vehicle prototypes to validate the simplification of the usability process.

5. Acknowledgements

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