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GESTURAL LOCOMOTION IN 360º VIRTUAL TOUR OF COIMBRA

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ABSTRACT

The locomotion between 360º images in virtual reality environments can be challenging due to the limited types of possible movements. In this work we created a virtual tour of the city of Coimbra to study the locomotion between 360º images through the usage of gestures. To accomplish this, we resorted to the usage of the Myo armband which can read up to 5 pre-defined gestures. These gestures allow the navigation between images, such as go to the previous location, to the next location or look at a map and select a location to go to. It is also possible to trigger other types of actions that do not involve locomotion such as, for example, open pop-ups containing information. We ran usability tests to evaluate the experience of this virtual visit, which allowed us to conclude that the majority of the participants believed they were in a virtual environment but felt some vision related discomfort. Not only that, but users thought that the gestures used to trigger the features of the application were natural and intuitive.

KEYWORDS

Virtual Reality, 360º Images, Locomotion, Myo Armband, Gesture Control

1. INTRODUCTION

Virtual Reality (VR) is a concept that was defined by Ivan Sutherland, in 1965, by presenting *The Ultimate Display*. The VR experience consists of placing the user in a world generated by a computer. Through this unique experience, you participate by interacting with virtual objects that can simulate the physical world, which are not limited by the same constraints, such as laws of physics and time. To improve the interaction within a virtual environment the contact with the virtual world must be as natural as possible, unlike what happens with conventional hardware. With the introduction of gesture identifying devices, the user can select and manipulate objects in an intuitive fashion. The tools used for the execution of our software were a VR headset alongside a Myo armband. The Myo armband is a bracelet capable of detecting the user's movement and up to 5 pre-defined gestures, allowing interaction without the need of touch. Our solution was to develop an application that allows its user to virtually visit Coimbra's emblematic locations. Through the usage of VR headsets, the user can view every detail of the 360º images of the selected locations, while also being able to interact with them through the usage of the Myo armband.

2. RELATED WORKS

In virtual reality environments, locomotion and interaction have been the subject of many studies, and as such, are regularly evaluated in order to verify potential solutions.

One of these solutions is the use of the Myo armband, which, since its launch, has roused a great interest in this field. Below, we describe some works that benefited from using Myo in VR.

McCullough et al proposed a navigation technique to explore virtual environments, by detecting the movement of the arm using Myo, this movement is then translated as a walk through the virtual space. This is a good method, however, it is not applicable in the context of our work because it implies locomotion in a 3D VR environment built in such a way that allows free movement through the space, while our objective is to navigate between various 360º images.

Bonome et al. also explored the use of Myo in VR, however, focused on its ability as an interaction and feedback tool as opposed to its locomotive use. They tested the usability of Myo in the selection and manipulation of 3D objects in a virtual environment and used the armbands vibrations as a feedback system. They concluded that the use of the Myo with this purpose in mind could enrich the user experience, making it more realistic, by using the measure of the force applied to a gesture and using Myo vibrations as a feedback system. This study shows interesting results relative to the usability of the armband to interact with objects, however it does not address the question of locomotion, which is our main focus.

When it comes to locomotion between 360º images in VR, some works approach solutions that do not utilize Myo.

Bozgeyikli et al. describe the technique "Point Teleport" and compare it to other more common usages - walking in place and joystick. With this technique the users simply point to where they want to go in the virtual world and then are teleported to said point. Their analysis of this technique showed that it is a user friendly form of locomotion that does not induce nausea caused by the movement unlike other techniques they compared. This a solution comparable to our solution of locomotion through Myo.

Another study by Pai et al. proposes the "GazeSphere" which provides a smooth transition between locations in a 360º video environment, through the usage of the movement in orbit, considering the head rotation and eye gaze tracking. This approach has several advantages, such as the usage of the human's natural sense of rotation used for locomotion that makes the actions intuitive and the use of eye tracking allows locomotion without the use of any extra device and in a more discreet manner.

Considering all these references, we gained knowledge of various forms of benefitting from Myo in VR environments and also other solutions that do not utilize Myo, but allow the locomotion between 360º images which are comparable to our approach. We also learned that our work is distinguishable from others due to the use of the Myo armband, specifically for the locomotion between 360º images in VR which requires jumping from one point to the other and, therefore, is a different approach from the others.

3. METHODOLOGY

Our system contains multiple high quality 360º pictures of the most well-known places located in the city of Coimbra which can be viewed by the user in a virtual environment in order to have a better idea of how Coimbra truly looks like compared to simple 2D pictures. The system also enables a natural navigation between the images of each location by using a map as a menu for navigation, as well as navigation with hand gestures. These methods were selected so as to not distract the user from the purpose of the system which is to view the most famous locations of the city of Coimbra.

The development of the application was not a simple and immediate software implementation process. It was divided by tasks, which we present below:

3.1 Creation of Personas and Scenarios

With the intention of minimizing the amount of complex alterations needed in the more advanced development phase, we started by creating personas and realistic scenarios involving the usage of the application, with the intention of focusing on our target audience in the context of the usages of the application. It was created a persona who was a potential tourist who goes to a travel agency to plan a trip to Coimbra, Portugal. It is in the travel agency that the application and the necessary equipment for its use are available and where the potential tourist uses the developed application.

3.2 Tasks and Cognitive Walkthrough

After we defined where the application will be accessible, the necessary accessories and who we are designing it for, the next step was designing the application itself, keeping the necessary functions and execution of said functions in mind.

In order to facilitate the development of the application, a task list was created that would always be accessible and would allow the team to confirm which features the application should have in order to meet the projected tasks. The cognitive walkthrough allowed the group to predict how to carry out interactions between future users and the application, along with the ability to foresee possible interaction issues in the future.

3.3 Development of a Prototype

Having the application's features and interactions with the system specified, we started developing a system prototype. This prototype allowed us to verify the feasibility of the features we had planned to implement in the system and to discover usability issues that would later be resolved. The following is a brief description of the application's components that were used to develop the prototype:

3.3.1 A-Frame

Our application uses web pages built using the A-Frame framework. They are 360º web pages with interactions triggered by the users focus (where they are looking), making use of the 3D object positioning provided the A-Frame. The user can trigger an informative pop-up of the location, of the map and of a specific point at which they are looking at.

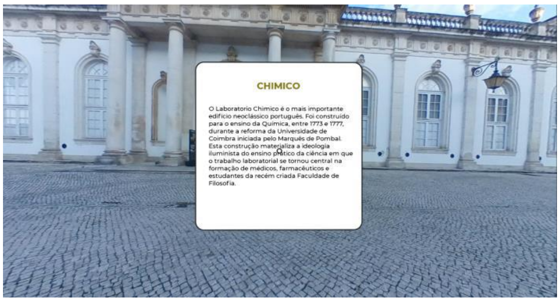

Figure 1. Pop-up with information of the location

Figure 2. Map with points of interest

3.3.2 MYO Armband

In our application, actions are triggered even when not wearing the VR headset. With a higher quality level of interaction and a better immersion experience inside the virtual environment in mind, we resorted to the Myo armband. Between the 5 pre-defined gestures, we picked 4 of them. Each of the 4 recognized gestures (fist, wave left, wave right and spread fingers) was associated with an action, which the system recognizes as a keyboard or mouse input. The fist gesture corresponds to a click in a location of the map (in which the focus of the VR headset and the direction the user is looking at function as a mouse pointer). The wave left gesture allows the user to return to the previous image (the location previous to the one they are in). The wave right gesture allows the user to continue to the next image (the next location). Finally, the spread fingers gesture first allows the user to open a pop-up with information on the location and, if that pop-up is already visible, allows the user to close it.

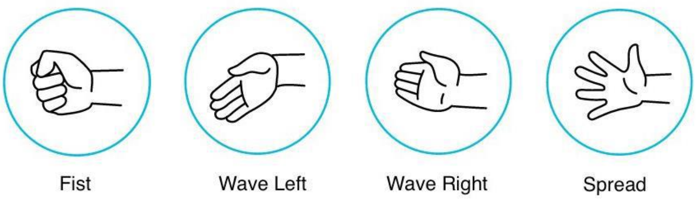

Figure 3. Myo Armband gestures used in the application

3.4 Performing Usability Tests

The prototype was then subjected to usability tests, which allowed us to reach conclusions regarding the experience of virtual reality, the ease of interaction, the possible side-effects and the limitations of the technology used in order to ensure the efficient use of the system. Ten participants took part in the test and in the end they had to answer two questionnaires adapted to our project: the Simulator Sickness Questionnaire and the Slater-Usoh-Steed Questionnaire. The tested users started off by receiving a tutorial on how to use Myo armband and what gestures corresponded to what features. After the tutorial, the user had the opportunity to explore the application a little more freely. Sometimes the person giving the tutorial asked the users to perform certain actions so the evaluators could take notes of how the user proceeded, if he remembered what he learned in the tutorial and whether the navigation through the environment was intuitive. Finally, the user answered the two usability questionnaires.

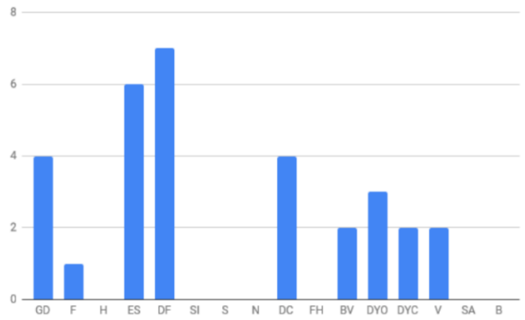

Figure 4. Simulator Sickness Questionnaire

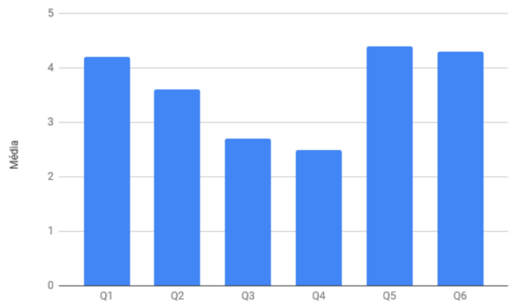

Figure 5. Slatrer-Usoh-Steed Questionnaire

The first questionnaire's objective is to determine whether the tester felt any type of physical discomfort or other symptoms during the usages of the software, like Headache (H), Salivation increasing (SI), Sweating (S), Nausea (N), Fullness of the head (FH), Stomach awareness (SA), Burping (B), Eye strain (ES), Difficulty focusing (DF), General discomfort (GD), Fatigue (F), Difficulty concentrating (DC), Blurred vision (BV), Dizziness with eyes open (DYO), Dizziness with eyes closed (DYC) and Vertigo (V).

The second questionnaire evaluates how immersive the VR environment is, the efficiency of the gesture execution and if the selected gestures are intuitive enough for the average user. The following questions were the ones in the questionnaire:

- Q1: Evaluate the virtual reality experience.
- Q2: During the experiment, how much did you believe to be in a virtual environment?
- Q3: When you recall the experience, do the memories remind you of just images, or a sense of having actually visited the sites?
- Q4: During the experiment, did you feel as if you were in a virtual environment or another kind of reality?
- Q5: During the experiment you used Myo to perform certain actions. Assess how intuitive the interactions were.
- Q6: Actions performed through Myo are triggered by gestures performed. Assess how effective (in the sense of being intentional) were the gestures you made.

4. CONCLUSION

After finishing the tests, it was clear that not all participants adapted well to using the Myo and the device would often not detect the gesture that they were performing, or it detected a different gesture. Furthermore, some gestures were less intuitive than others.

Some participants reported that the transition time between images was long and that it broke the immersion of the 360º environment.

Finally, we noticed that after the tutorial, when the users were allowed to use the program freely, they felt lost, since they knew that wave right led them to the next location and wave left returned them to the previous location, but after selecting a location in the map many users expected that wave left would bring them to the location they were previously in instead of the previous one in the route defined by the program, that is, the wave gestures were predefined, a fact that was not obvious to the users. A possible solution to mitigate this problem would be to color code in the map, the next and previous locations in the predefined route starting from the location that the user is in, so that they do not get lost navigating through the application.

The development of this application has allowed us to not only study the planning and development of the software, but also to analyze technologies that we had never had access to before to develop content, namely the Myo armband and the HTC Vive VR headset.

In general, despite the problems we identified, we believe that approaching locomotion in a virtual reality setting with the Myo armband vastly enriches the experience of the user. The interaction between the 360º images through gestures using the armband doesn't break the immersion and allows the user to control their surroundings, using hardware that does not require extensive time to learn how to use.

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