User Experience Evaluation with Archaeometry Interactive Tools in Virtual Reality Environment

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ABSTRACT

In this work we present a study about usability experience of users in a cyber-archeological environment. We researched how they explore a realistic 3D environment in Virtual Reality (VR) through archaeometry conventional techniques. Our objective is to evaluate users experiences with interactive archaeometry tools with archaeologist (not a VR expert) and compare results with VR experts (not an archeology expert). Two hypothesis will be tested: a) it's possible to simulate the virtual world realistically as the real one?; b) if this VR model is passive of exploration, is it possible to create 3DUI analytical tools to help archaeologist to manipulate archaeometry tools? To explore these hypotheses we conducted experimental tests with ten users and the results are promising.

Keywords: Usability, virtual reality, user experience, cyber-archeology, virtual continuum.

Index Terms: H.5.2. [User Interfaces]: Evaluation/Methodology.

1 CYBER-ARCHEOLOGY

It is well known archeological sites are fragile and susceptible to destruction [1]. During an archeological dig procedure the original information may never be recovered. In addition, archeological spots are ephemeral places [1]. So, having the digital record of these sites is a way to preserve it [2].

For those reasons, we created a VR simulation of Itapeva Rocky Shelter, a pre-historic archeological site in Brazil. This cyber-archeological site is visualized through a head-mounted display. Also, we designed 3 virtual archeometry tools for user interactions (annotation, rock painting and artifact classification).

We intend to conduct an initial but effective evaluation of users experiences with interactive archeometry tools. Two hypothesis will be tested: a) it is possible to represent the virtual environment (VE) realistically as the real environment (RE), in such way that a not expert with this technology, in this case the archaeologist, can develop analytical discoveries?; and b) if this VR model is passive of exploration, is it possible to create analytical tools that will help the archaeologist to manipulate archaeometry tools?

2 VIRTUAL CONTINUUM IN CYBER-ARCHEOLOGY

Today VR has a huge variety of environment systems. To classify those environments through a functional taxonomy Milgram and Kishino [3] developed the Virtuality Continuum (Figure 1).

This is important for us because it creates an extension of the archeologist research. It means, VR exploration may emerges like a continuous flow of their work: the archaeologist in the loop (*i.e.* user analyzing rock paintings in lab facilities, not through a photo or video, but as if she/he was transposed to the natural field).

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3 MATERIALS AND METHODS

Following we present the methodology, tasks, materials and settings applied to conduct the empirical study with volunteers.

3.1 Study Sample and Settings

Volunteers in the experiment were separated in two groups:

- **Group A:** five VR experts
- **Group B:** five professional archaeologists or students

A pilot test was conducted with an archaeologist to validate our test protocol and also to estimate the total time spent training (learning phase) and executing tasks. Tests were applied in a usability lab equipped with table, chair, notebook computer, HMD (HTC Vive), 3D input device (SteamVR) and a video camera.

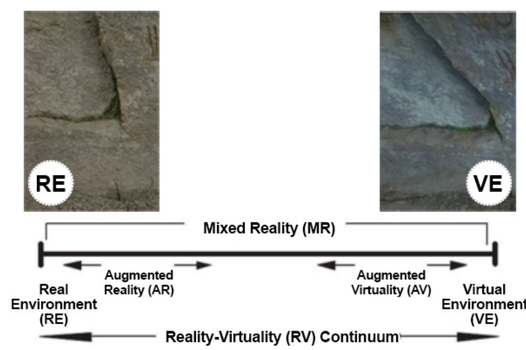

Figure 1: Virtual Continuum in the cyber-archeology field.

3.2 Instruments and Outcomes Measures

Demographic, IT/VR knowledge and usability measures.

- **Demographics and IT/RV Knowledge and Experience**

A pre-tested questionnaire was applied at the beginning of each session to assess the volunteers experience with VR and/or digital game narratives. They were asked about their age, gender, education and preview experience with videogames or VR devices, including here the frequency of use (Group B) and/or the frequency of visits to the archaeological site of Itapeva (Group A)

- **Tasks and Scenarios**

Tasks were defined using system's functionalities. They're structured in the following order: creating points of interest; creating notes; creating painting; editing notes; editing paintings; using teleportation tool; removing notes; removing paintings; deleting point of interest; accesing visual transition (to compare computer graphics scenario with a 360º photo).

The usability assessment tasks were listed from scenarios:

a) **Scenario 1 - Creating Artifacts:** create a point of interest named "point 1". Inside it create a text note named "register 1" and enter the text "register rock". Then create a painting of a man's toothpick in blue color and name it "paint 1".

b) **Scenario 2 - Editing Artifacts:** change the contents of "register one" to "rupestrian register 2015". Then redo the "paint 1" drawing the same toothpick but in red with the stroke thickness in 25 mm and depth 0.8 mm.
c) **Scenario 3 - Moving Around the Scene:** move yourself to behind the big rock. Then, return to your point of origin.
d) **Scenario 4 - Creating New Artifacts:** use the teleport command to create another point of interest behind the big rock and call it "point 2". Inside it, create a text note called "register 2" and enter the text "register 2016". Then, create a painting of a man toothpick in yellow and name it "paint 2".
e) **Scenario 5 - Deleting Artifacts:** you have created two points of interest on the wall. So now, delete the "register 2" inside the "point 2". Finally, delete "point 1" and "point 2".
f) **Scenario 6 - Transition:** make the transition from the virtual (computer graphics) to the real scene (360º photography).

3.3 Usability Measures

Established by ISO 9241-11, usability metrics (efficacy, efficiency and satisfaction) were collected from questionnaires.

Efficacy was calculated through success of completing tasks and by number of errors occurred during the interactions.

Efficiency includes user effort and use of resources to achieve goals. It is related to the execution of tasks quickly as possible.

Also, we applied Slater-Usoh-Steed Questionnaire (SUS) [4]. It's a six questions research, ranging from the minimal (1 = low presence feeling) to maximum (7 = high presence feeling).

The satisfaction of the interactions was measured through the System Usability Scale (SUS) questionnaire.

We also used the Simulator Sickness Questionnaire [5] to measure symptoms of cybersickness.

Video recordings were analyzed in order to encode the specific metrics: success rate, error and time of each task. Sessions ended with questionnaires: a) SUS of Presence (6 questions), Interaction SUS (10 questions) and Cybersickness (8 questions). Each test had average duration of 30 minutes per participant.

4 Results and Discussion

Following we present results and discussions about data collected during the empirical experience with 10 volunteers.

4.1 Effectiveness

Figure 2 shows task effectiveness by Group A. Scenario 3 was the easiest tasks. Scenario 4 and 5 were the most difficult to complete with an error indices of 26% and 32%, respectively.

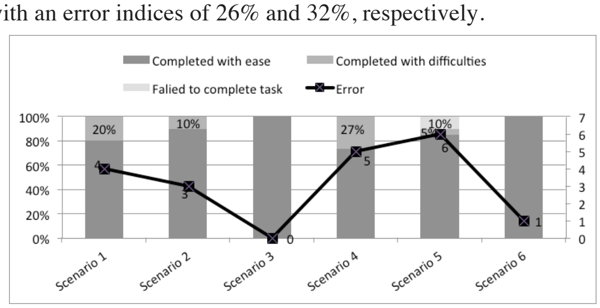

Figure 2: Effectiveness of the tasks performances by Group A

Figure 3 shows results of task effectiveness by Group B. Similarly to Group A, the tasks in Scenario 3 were the easiest to accomplish, being completed easily and with no errors. Scenario 1, 2 and 5 were the most difficult.

4.2 Efficiency

Scenario 1, 2 and 4 performed by Group B consumed as much time as expected. These tasks involved typing actions to insert texts and draw that demand a greater effort. Tasks on scenario 3, 5 and 6 were the quickest.

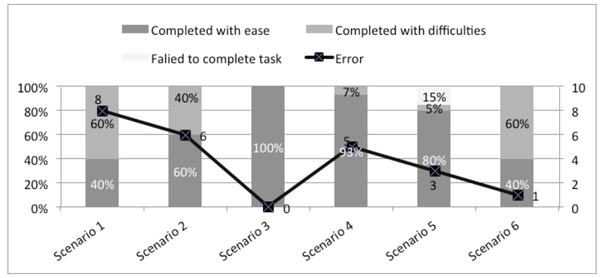

Figure 3: Effectiveness of the tasks performed by Group B

4.3 System Usability Scale (SUS)

Average score of SUS interactions for the whole group (A + B) was 78.5. It is a good satisfaction among users (archaeologists and VR experts). However, there were variations in the scores with a minimum value of 70.0 and maximum of 97.5.

4.4 Slater-Usoh-Steed Questionnaire

It was notable that both groups attributed high scores to questions related to the perception of presence in the VR context. On a Likert-Scale (1 to 7), no average response was below 4.6 points.

4.5 Sickness Questionnaire

Nausea and oculomotor-related symptoms were relatively low. Group B presented vertigo at a moderate level. Group A presented symptoms related to the motor oculus (*i.e.* blurred vision).

5 Conclusion

This study demonstrated the application of systematic usability methods during cyber system interactions. Our results showed how the usability standard of ISO 9241-11 can be used for a set of efficiency, efficiency and satisfaction measures. We also analyzed levels of presence in the VE and issues related to cybersickness.

We may concluded that it is possible to represent VE realisticly as the real one, in such way an archeologist (unfamiliar with VR) still develops the analytical process of discovering (Hypothesis 1 = true). Also, the data collected by the usability tests revealed us the analytical potential created by our 3DUI tools (text note, paintings, teleportation). So, yes the VR model is passive of exploration (Hypothesis 2, part 1 = true). Anyway, we must to improve the tools to become a more intuitive operation for archaeologists (Hypothesis 2, part 2 = true and false).

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