Dissemination of Cultural Heritage: Design and Implementation of a VR environment for the preservation of art and culture in the Canton Pujilí - Ecuador

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***Abstract*— Technology through time has been a fundamental mean in the development and cultural evolution, changing the perspective of the human being with the world in relation to the reconstruction of memory and the historical past. In this context, Ecuador seeks to adapt to the rapid changes of the technological era and solve the problems caused by the pandemic caused by the outbreak of COVID-19 in early 2020, in the interruption of cultural and economic activities. At the local level, Pujilí, Land of the DANZANTE, considered intangible cultural heritage of humanity, has not been exempt from this situation, being the Cultural area the most affected. For this reason, the current research, PUJILÍ MUSEUM, proposes a means of dissemination and preservation of Art and Culture, adapted to current changes, through a Virtual Reality mobile application that integrates 3D modeling technologies and reconstruction by Photogrammetry, to improve the quality and immersion, allowing visitors to immerse themselves in a world full of history, art and culture, music, and tradition. The application was tested by 30 users/visitors who had mid/high range mobile devices, applying the convenience sampling technique, in order to know the levels of satisfaction and learning of the different interactive areas. The experimental results showed a positive effect on visitors and a high level of acceptance when using the virtual environment. This has been corroborated by the number of downloads, ratings, and reviews.**

***Keywords*— art, coroutines, cultural heritage, culture, dissemination, environment, preservation, virtual reality.**

I. INTRODUCTION

Virtual Reality (VR) is defined as "The confluence of immersion, interaction and imagination" [1, 2] that allows the user to interact and immerse in an artificial environment. Its development began in the 1950s, and its evolution is directly related to technological and software advances [3, 4]. Currently, its use is widespread in various academic, industrial, technological, research and scientific-artistic contexts [5, 6], where the user perceives a variety of sensory stimuli (such as vision, hearing, touch, even smell and taste) in environments that only exist in the computer [7, 8]. These environments commonly support teaching and learning processes, which capture real/natural movements in the virtual world.

The use of Information Technologies (ICT) and the latest techniques in 3D design, photogrammetry, and VR [9] in the construction of virtual heritages such as: museums, monuments, sculptures, libraries, among others, represent a great potential to reconstruct the past and memory, by creating virtual environments that show high quality realistic contents [10]. Usually, environments can be natural (a landscape) or artificial (an industrial complex) and some even allow access to environments impossible to reach in the real world, because they are too deep (underwater environment), too far away (extra-planetary environments) or too dangerous (a nuclear power plant) [11]. In these environments, users interact in a natural way by moving freely [12].

The rapid dissemination of mobile devices that adapt to immersive environments has configured new conditions in the

field of culture and tourism [13], causing in some productive sectors such as the tourism and cultural sector its evolution and incorporation of technologies that allow showing art, culture, history, among others. The development of mobile applications, where tourist-cultural destinations are incorporated, allow access to available information, and expand the different forms of tourism in which even visitors are part of the environment [14]. In this context, the applicability of museum visits and virtual tours varies from fully immersive adaptive systems to multimedia presentations. Exemplified in: The Tower of Pisa website [15], The Louvre Museum [16] and The Hermitage Museum [17]. In this same sense, the dissemination and preservation of Cultural Heritage is a concern and challenge, due to various factors such as climate and weather that deteriorate the physical infrastructure [18], therefore, projects such as La Tarragona, have managed to preserve and virtualize part of the ancient Roman power [19], demonstrating that virtualization is the next step.

Based on the background, we seek to address the problems that have arisen due to the pandemic, threatening financial survival and tourism development, through the application of VR on mobile devices [20], replacing old patterns of cultural dissemination (festivities, public and private events, traditional festivals, exhibitions) with new technologies in order to ensure safety and modernize the visualization of cultural heritage. This project presents a 3D virtual environment that contributes to the dissemination and preservation of art and culture by combining artistic and cultural inspirations with futuristic design solutions (photogrammetry, 3D reconstruction, open world development techniques) in a way that does not affect cultural identity, but offers the user a better perception of the content [21], and provides an enhanced, vivid and enjoyable presentation of the city of Pujilí/Ecuador, stimulating their learning motivation, breaking real-world boundaries towards a broader immersion of creative imagination [21] and reaching places where information is the main impediment.

II. Background

A. *Cultural Heritage and ICTs.*

Since the emergence of new technologies and media as an instrument of knowledge of cultural heritage, public and private institutions and companies worldwide have made efforts to incorporate them as a conduit for the transmission of ideas, addressing the needs of visitors to access content in new and exciting ways in order to increase the dissemination of knowledge through the safeguarding and preservation of culture.

Technologies such as computer vision, virtual reality or artificial intelligence itself, when combined, allow the dissemination of art and culture, improving their interaction with a wider audience, such as virtual tours and MMO or massively multiplayer games, which maintain their own artistic level and demonstrate that virtual environments are a viable way to strengthen the history of humanity.

B. *Tourism in Pujilí*

Tourism is an important incentive for local development of a large number of urban and rural areas, allows to boost traditional economic activities and enhance local culture, in the case of Canton Pujilí, both local and foreign tourism has remained constant having an approximate of 8920 to 9000 tourists both foreign and domestic since 2014 until the beginning of the pandemic caused by COVID-19 in early 2020, falling sharply, with an approximate of 6051 tourists, where, The main attraction remained "La Laguna del Quillota", leaving other areas such as Pujilí itself with approximately 644 tourists, of which 90% used the city as a means of passage to other destinations, producing the closure of both businesses and historical sites, in addition to affecting other means such as gastronomy, leaving the population without a means of survival, for this reason the creation of multimedia to encourage tourists is the right path towards the revival of the Canton Pujilí.

III. System Architecture

The design of the applied software outlines an architecture focused on two sections: the development of virtual environments and the structure that involves applications with an educational model, presented in Fig.1, generating a technological stack focused on the optimization of virtual environments and the dissemination of knowledge for mobile devices.

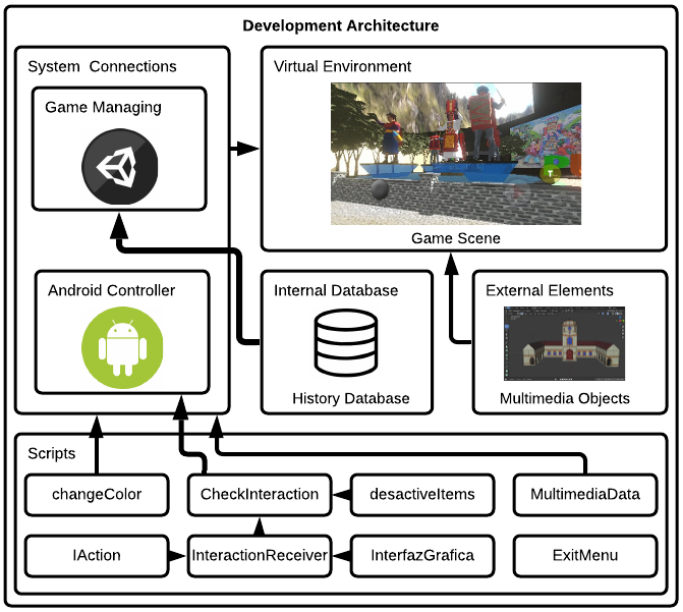

Fig. 1. Proposed System Architecture.

The proposed architecture presents 5 modules: (i) System Connections: responsible for the integration of each module and for controlling the internal processes of the application. (ii) Scripts: corresponds to the coding of each of the functionalities and their respective internal controllers (iii) Internal Database: the database used by the application contains the history and information of Cantón Pujilí and through Blueprints the objects that will be presented in the exhibition are called. (iv) External Elements: corresponds to each created or reconstructed element that will be part of the virtual environment. (v) Virtual Environment: Represents the running system.

Finally, the use of Coroutines improves the accuracy of the system when emulating complex processes, allowing the work in parallel with the execution of the main processes [22], as a

result, wider action chains are obtained, emulating situations closer to reality, without affecting the performance of the application, as explained in Fig.2.

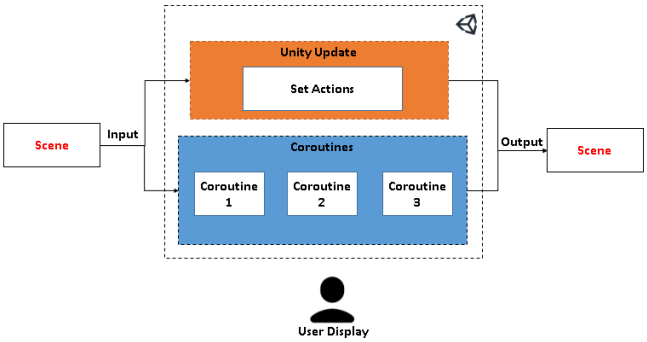

Fig. 2. Proposed Coroutine Scheme.

IV. SYSTEM DEVELOPMENT

A. *Development Structure.*

The development of PUJILÍ MUSEUM consists of five modules (See Fig.3), from the modeling and construction of the application, to its launching to production:

1) Reconstruction and Modeling of monuments and historic building: Implementing the proposed algorithms of camera tracking and 3D reconstruction provided by the computer vision framework AliceVision [23], we proceeded to the digital reconstruction of the Cultural Heritage of Pujili using the program MESHROOM [24], which allows the creation of three-dimensional compositions from related photographs.

2) Modeling and Texturing of the Cultural Heritage of Cantón Pujilí: The modeling of artistic assets and additional buildings was carried out through high-resolution photographs, using the freely distributed tool Blender [25], which also allowed the integration of the textures corresponding to each of the models generated.

3) Integration of 3D Models and Structures within the development environment and Construction of the virtual environment: The virtual environment was created using the UNITY development engine [26]. The environment consists of an adaptive area for the user, a main area and several rooms that simulate an open world, finally, the use of Post Procesing in the management of lighting and finishing, increased the realism of the environment.

4) Coding of Actions and Controllers: Using Visual Studio [27], a tool that supports interaction with UNITY, we proceeded to the creation of each of the mechanics established within the virtual environment, in addition, we created controllers and implemented Coroutines that allow the operation and connection of the application..

5) E xecution and production launch of PUJILÍ MUSEUM: The size of the application is 399 MB and since the maximum limit is 150 MB in the Play Store (Virtual Store used for the launch of the application), the application was divided into two packages, generating an APK with the main functionalities and an .obb file as an expansion package. Finally, the application file was created and the application was uploaded for subsequent download.

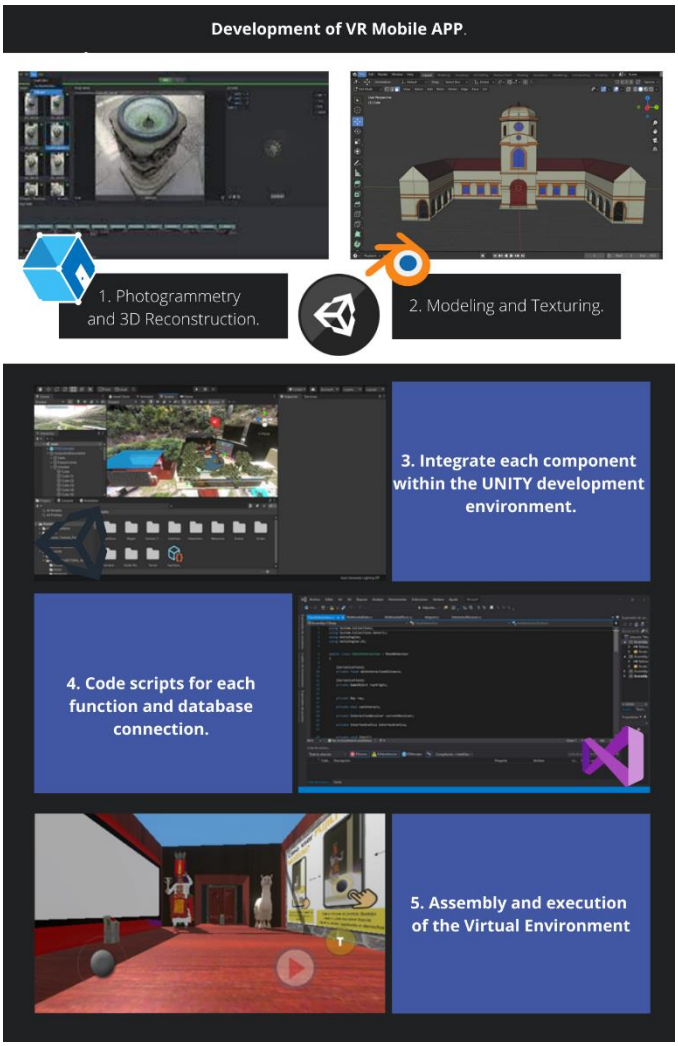

Fig. 3. Development of the virtual environment APP.

V. RESULTS AND DISCUSSION

This section presents the results obtained in the development and implementation of the virtual environment for the dissemination and preservation of art and culture of the Canton Pujili. These results are divided into two stages, i) Interaction with the system, which details the functionality of the application developed through the main attractions of the virtual environment and ii) Validation of the application, which analyzes the results obtained from the manipulation of the system by a group of users.

A. *Interaction with the System.*

To access the virtual environment, it is necessary to consider the specifications that the mobile device must meet, such as

6GB of RAM memory, Android version 10 or higher and 400MB of available space. Next, the application must be downloaded. Once the user/visitor accesses PUJILÍ MUSEUM, he/she must tap on the "START" button to enter and immerse him/herself in the cultural heritage of Pujilí. (1) The application has an adaptation area for the user/visitor to explore and adapt to the functionalities and mechanics implemented in the environment. Upon familiarizing with the environment, (2) The user/visitor is introduced to an unreal world, where the main entrance to Cantón Pujilí shows an iconic 3D reconstruction through its monument. The journey continues to the exhibition of much of the history, art and culture, music, and traditions through the playback of audios that briefly explain each interactive area. In addition, monuments and representative buildings of the city are displayed. (4) Finally, there are special sections that offer unique experiences regarding the festivities, tourist sites and religious sites of the Canton (See Fig.4.).

PUJILÍ MUSEUM has reconstructions of monuments, buildings, characters, churches, in order to preserve the cultural heritage and provide an unforgettable journey into the different areas: history, art and culture, traditions, music and tourist sites. The application adapts to the different screen sizes of mobile devices.

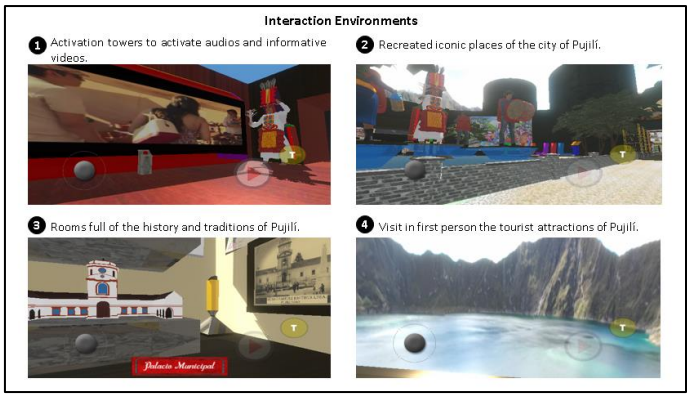

Fig. 4. Interactive System Environments.

B. *Validation.*

I) Experimental Results

Using the convenience sampling technique, 30 users/visitors who had never visited the city of Pujilí/Ecuador were selected as respondents. After a brief general introduction to PUJILÍ MUSEUM, each of the users/visitors uses their smartphone, which already has the application installed. The participants begin to have a pleasant experience by visiting different areas that show the cultural heritage of the city, which are: history, art and culture, traditions, music and additionally tourist sites (See Fig..5). The immersive virtual museum visit session ranges from 30 to 45 minutes. At the end of the tour through the entire virtual museum, users/visitors are asked to take an aptitude test.

Fig. 5. Users/visitors are immersed in an interactive and entertaining virtual environment.

To give consistency to the aptitude test, a reliability analysis was first performed using Cronbach's alpha (Fig. 6), which yielded a value of 0.8151, indicating that the measurement items (questions) were positively correlated, so that all constructs were considered reliable [28].

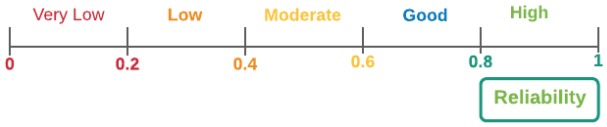

Fig. 6. Cronhach Alpha Scale.

The formula applied was, by means of the variance of items:

$$\alpha = \frac{k}{k-1}\left[1 - \frac{\sum V_i}{V_t}\right] \quad (1)$$

$\boldsymbol{\alpha}$: Cronbach's alpha

$\boldsymbol{k}$: Number of items

$\boldsymbol{V_i}$: Variance of each item

$\boldsymbol{V_t}$: Variance of the total

Next, the aptitude test [29] was applied, which is designed to analyze the effects of the learning process and the levels of dissemination and preservation, based on the integration of the environment with tourism through the PUJILÍ MUSEUM application. The results show that the general opinions of the visitors were as follows:

- The learning of general knowledge of the city of Pujilí, culture, history. music and tradition showed a moderate improvement ($\bar{X}$=3.7, SD=1.00).
- The route presented in the virtual environment was satisfactory ($\bar{X}$=4.1, SD=0.92).
- The usefulness of the PUJILÍ MUSEUM application was considered quite good ($\bar{X}$=4.7, SD=0.53).
- The "enjoyment capacity" of the PUJILÍ MUSEUM application was considered good ($\bar{X}$=4.3, SD=0.83).
- The exposed contents were of great help to spread the art and culture of Cantón Pujilí ($\bar{X}$=4, SD=0.69).

- PUJILÍ MUSEUM helped in the preservation of the cultural heritage (monuments, buildings, churches) ($\bar{X}$=4.33, SD=0.66).
- PUJILÍ MUSEUM was in line with their expectations ($\bar{X}$=4.03, SD=0.66).

Additionally, the System Usability Scale (SUS) was applied to measure the usability of the application. SUS has a 10-question questionnaire with five options for each one of them. The results are tabulated, and the usability score is calculated, with 100 being the maximum value and 0 the minimum. In case of obtaining a value higher than 80, it is said that the application has a high degree of usability for users/visitors, on the other hand, if the value is lower than 68, it is considered to be below average.
The results shown in Table 1 detail the calculations made and it can be considered that the application is easy to use, since the average usability of the system is 84.67.

TABLE I. APPLICATION USABILITY EVALUATION

Evaluated parameters	***Average***	***Weight***	***SUS Final Score***
1. I think that I would like to use PUJILÍ MUSEUM frequently.	4,13	x-1	3,13
2. I found PUJILÍ MUSEUM unnecessarily complex.	1,23	5-x	3,77
3. I thought PUJILÍ MUSEUM was easy to use.	3,63	x-1	2,63
4. I think that I would need the support of a technical person to be able to use PUJILÍ MUSEUM	1,06	5-x	3,93
5. I found the various functions in PUJILÍ MUSEUM were well integrated.	4,70	x-1	3,70
6. I thought there was too much inconsistency in PUJILÍ MUSEUM.	1,03	5-x	3,97
7. I would imagine that most people would learn to use PUJILÍ MUSEUM very.	4,23	x-1	3,23
8. I found PUJILÍ MUSEUM very cumbersome (awkward) to use.	2,97	5-x	2,03
9. I felt very confident using PUJILÍ MUSEUM.	4,60	x-1	3,60
10. I needed to learn a lot of things before I could get going with PUJILÍ MUSEUM.	1,13	5-x	3,87
Total Amount SUS Score			**33,87 84,67**

VI. CONCLUSION AND FUTURE WORK

In this work, we applied photogrammetry, 3D modeling and Postprocessing to develop the virtual environment that has a high value in the study of art and culture of the city of Pujilí/Ecuador. We used Unity software to present a high-quality scene through the reconstruction of 3D models of artworks in proportion, mapping the elegant texture of the real photograph to the 3D model with the use of CUDA and MESHROOM, rendering light/shadow, etc. With the help of our software, visitors can visualize the Virtual Museum from any angle and better understand the art and culture of the city.

PUJILÍ MUSEUM, was well received and accepted by visitors, due to the factors that influenced the virtual environment, such as realism, performance, physical immersion, and interactivity, which immersed the user into a world full of history, art and culture, music, traditions, and tourist attractions of the area. Being a mobile application uploaded to the Play Store platform, it could be available to all public, ensuring the largest audience and thus obtaining reviews and ratings that strengthened its purpose, preserve, and disseminate the art and culture of the city of Pujilí/Ecuador.
In future work, we plan to expand the application on computers and adapt the environment for the use of additional modules for mixed reality. In addition, we intend to provide the content in several languages to meet the expectations of visitors from different countries and not have any limitation in the dissemination of art and culture of the city.

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