Development of a computer platform for the enrichment of cultural environments using VR and AR

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***Abstract*—The implementation of technologies plays a very important role in the user experience within cultural spaces, allowing to add life to static objects in the real world with sounds, visual content and additional information. In this work we propose a web platform design for registration of works that allows and provides support to cultural sites, registering and digitizing their various works, sculptures or exhibition sites, regardless of the technique implemented in these. In addition, technological tools such as vuforia and unity are used to create a mobile application that turns a smartphone into a personal guide that can not only provide textual stories, but can also perform virtual tours of the installations. The functionality of this platform is evaluated by implementing it in a gallery located at the Don Bosco University, demonstrating its versatility.**

***Index Terms*—Augmented Reality, Virtual Reality, computer platform, culture**

I. Introduction

Social and technological trends are the reference point for various innovation projects that are currently implemented in order to obtain profitable results and guarantee success; showing us that contemporary society is evolving exponentially towards technology oriented to user experience, with the improvement and reinvention of many sectors according to Paola [1]. This work is framed in the need to develop a digital platform for the creation of virtual reality and augmented reality applications, which can be used as support in cultural sites for the dissemination of these through the use of interactive interfaces that enrich the cultural experience of users. These museums, interpretation centers and archaeological parks are places that must incorporate these technologies, especially to ensure that the new generations of visitors find the digital experience they are looking for, turning these cultural spaces into places of digital literacy [2] [3] [4]. Currently, the integration of VR(Virtual reality) and AR(Augmented Reality) [5] in museums, interpretation centers and archaeological parks is enriching the tours and visits in these cultural spaces [6]. When we talk about enrichment in cultural activities, it is based on the use of technological devices that users carry in their pockets, such as cell phones, cameras or tablets. It is noteworthy that to provide this interactivity, it is essential that people make use of their own devices in the halls of museums, exhibitions, auditoriums and archaeological parks. It should also be noted that this does not represent a problem for these cultural spaces, since worldwide the number of users with smartphones exceeds 3 billion and is expected to continue to grow gradually over the coming years, as shown in the projections in Fig 1.

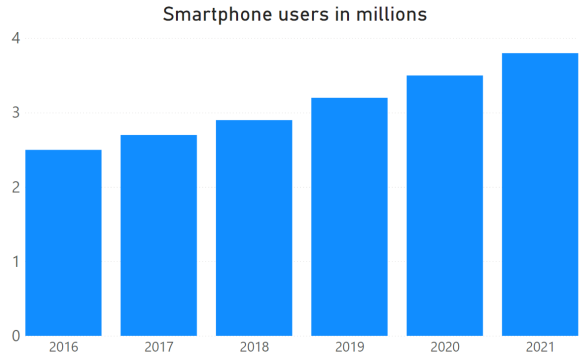

Fig. 1. Users with smartphones worldwide 2016-2021. Graph taken from Statista statistics.

Most of the existing digital platforms for cultural spaces have the disadvantage that they are designed to adapt specifically to museum exhibitions, not considering other types of existing cultural spaces such as archaeological parks and interpretation centers. Also, we can highlight that in general the existing platforms are developed in English language, are custom-made for a specific cultural space and cannot be reused in other sites.

Worldwide, similar work has been done to the development of our platform, but focused on the use of already created tools. Examples of these are the following: development of an augmented reality application for the telecommunication museum Vivente Miralles Segara, located in Valencia [7], development of an augmented reality application for the interactive installations of the project "The seven worlds of Samoga" [8], construction of an augmented reality viewer for

exhibitions located in closed environments [9]. We can also observe these types of projects in Spain, Mexico and Middle Eastern countries, which include archaeological preservation policies robust enough to encourage the incorporation of innovative technology as seen in the use of Augmented Reality Applied to Archaeology [10], Information and Communication Technologies for inclusive tourism [11] and advanced mobile applications for heritage sites [12]. An art gallery at the Don Bosco University was selected to evaluate the operation of this alternative digital platform, demonstrating that it can be implemented independently of the place or cultural space where it is to be used. For the development of this platform, unity and vuforia [13] are used, as well as VR and AR technologies.

II. Digital Platform Design and Model

Our platform comes to support cultural institutions such as museums, archaeological parks and interpretation centers, in order to enrich their tours through the digital experience, implementing technologies such as AR and VR, as well as offering an option of digitization of their works of art.

The platform developed in this work, allows to register authors of works, works of art and rooms belonging to the registered cultural center, storing this information in two parts. For the storage of the images we will use vuforia and for the rest of the information, it is processed in the PostgreSQL database.

The registration of the cultural space is done through a web app created exclusively for the capture of the data described above. The model of the museum platform that we will create can be seen in Fig. 2.

As we can see in Fig. 2, the main idea of this work is to implement a web platform based on React [14] language, from the website where the data is captured and stored in the PostgreSQL database, except for the images that must be stored in vuforia. For data security the web application has access to the data through an endpoint made with docker, which will have security for access through user authentication, where the web application must send a JSON web token(JWT) [15] in the authorization header of the HTTP(Hypertext Transfer Protocol) request to the backend API(Application Programming Interfaces). If the authentication is successfully sent, the web application receives the data and with this it can maintain the information displayed in the mobile application. The latter aims to enrich the content of the exhibits and create interactive experiences that generate greater impact on the user.

III. Augmented Reality and Virtual Reality Implementation

The mobile application provided by our platform has the ability to blend the real world with the virtual world, containing a section that is able to recognize the objects already registered in the web app and then displays digital objects to them, very similar to Google's ARCore technology and Apple's ARKit [16] which includes stable movements and plane estimation with basic limits.

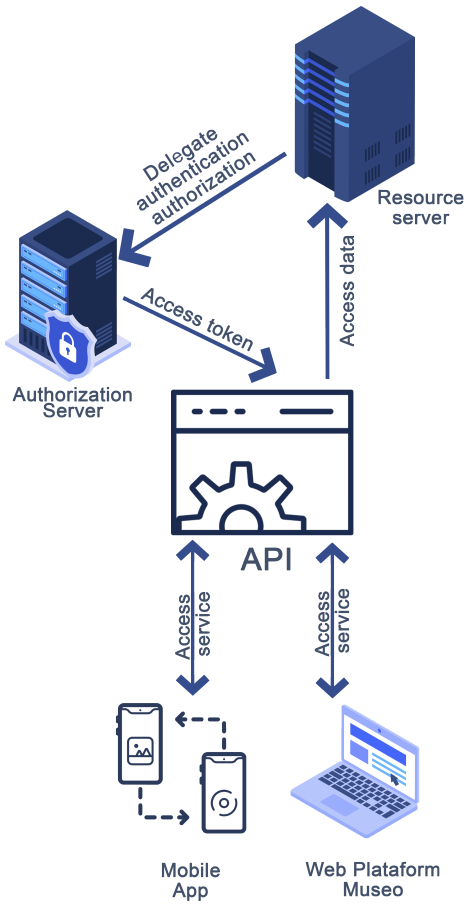

Fig. 2. Diagram of microservices used for the museum platform.

The VR and AR application functionality provided by our platform will depend, to a large extent, on the ecosystem of the mobile devices used such as: GPU(graphics processing unit), and their hardware characteristics (Central Processing Unit, camera and motion sensors). In Fig. 3 we can see how the mobile devices are used for the functionality of the AR application described above. As shown in Fig. 3, the terminal performs the tasks of capturing the scene and presenting the results, while the provider's server performs the rest of the processing, from scenario identification to image composition.

The images are processed by marker-based tracking [17], a marker being an image or object registered with the application, which acts as a trigger for information in the application. When the device camera recognizes the marker in the real world, while running the mobile application, this triggers the display of virtual content about the marker's world position in the camera view. Marker-based tracking can also include quick response code, where the physical markers are reflective; images must be registered in the application so that they can trigger the display of virtual content, for this it is important that the images contain distinct shapes with complex contours, in order to facilitate the operation of the image recognition and tracking algorithms.

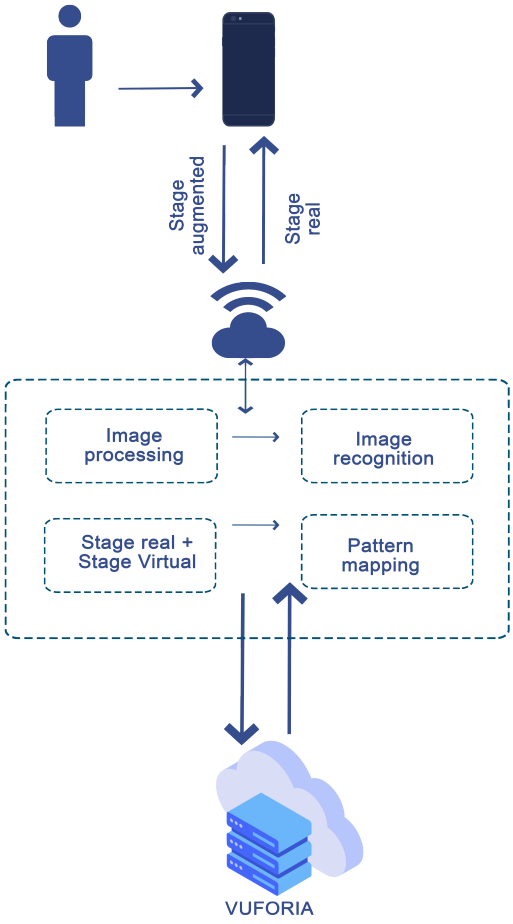

Fig. 3. Schematic of distributed system architecture used in app museum.

The application will have a section for a virtual tour [18], which is a faithful example of the physical space that can be found in the registered cultural space. The interactive virtual tours also add the possibility for the visitor to move between the different spaces that compose it, as well as to detail the important elements that are considered in it. Therefore, this type of virtual tours interact with the user giving him freedom of movement.

IV. Applying a Platform to an Art Gallery

Having described the operation and configuration of our platform, we proceed to implement it in a specific cultural space. We have chosen an art gallery located at the Don Bosco University (UDB), which has 179 works of art that are part of the heritage of this institution. The works are permanently exhibited in three exhibition halls called Florence Hill de Mathies, Meza Ayau and Maestro Armando Solís.

The implementation of the platform began with the digitalization of the 179 works of art, cataloging the following data for each one of them: name of the work of art, name of the exhibition hall, height and width dimensions of the work, the name of the author who made it and the technique he used. All these data are registered from our web platform, being entered in the following web form, shown in Fig. 4.

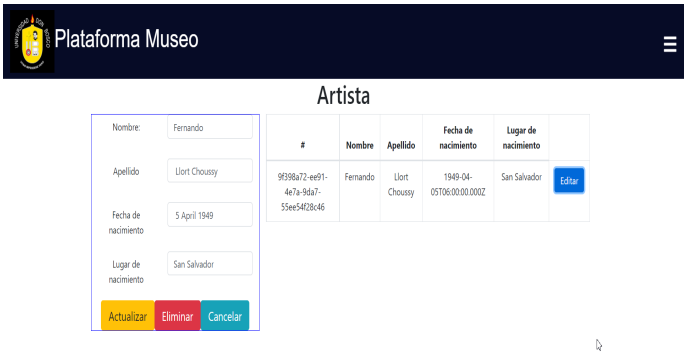

Fig. 4. Web form for data capture of the artwork to be digitized in the system.

When clicking on the add button of the form presented above, an alert message is displayed informing that the data were entered correctly and these are shown in a new row of the table located on the right side of the form in Fig. 4. With this information, we can now connect our mobile application to provide greater interactivity to visitors to the gallery, showing them the catalog, the interactivity with AR and the virtual tour of the gallery.

The museum platform has two components: the web part and the mobile part. The web app is developed in React and the mobile part in Unity, in order to add AR and VR components inside the application. We also use microservices for storage and authentication of both components.

To test the web app components and the mobile application, the web platform was used to digitize all the information about each painting, sculpture, stained glass, etc. belonging to the exhibition of the UDB art gallery. From this information, the mobile application is able to use the device's camera to capture the characteristics of a focused object in real time. Unity then uses these object features to generate the AR scenes using neural networks, fuzzy logic and artificial intelligence algorithms. Finally, the created AR scene is displayed on the device screen with the descriptive information corresponding to the focused object. The advantage is that the Software Development Kit Unity, provides native development support for iOS and Android, allowing the development of portable-friendly AR applications for both platforms. A photograph of the artwork is shown in Fig. 5 and the AR view provided by the mobile application of the artwork is shown in Fig. 6.

This application not only records paintings, but can also digitize stained glass as shown in fig. 7, which is a stained glass type artwork and then in fig. 8 we will show the view of the mobile application.

In the figures presented above, it is shown that with the digitization of the works and the incorporation of the information of the characteristics of these in the mobile application, it can

Fig. 5. Painting: Bodegon y paisajes by Roxanna Carboneli Source :Pinacoteca UDB.

Fig. 7. Painting: Lo nuestro by Eva Margarita Llort de sade Source :Pinacoteca UDB.

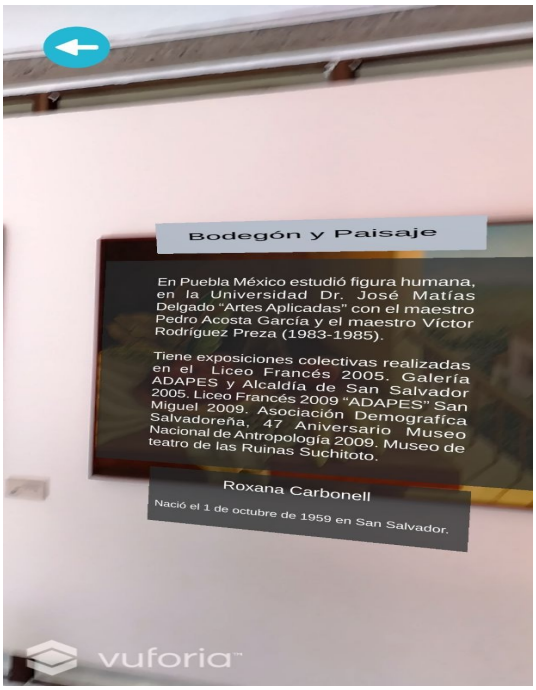

Fig. 6. Painting view Bodegon y paisajes by Roxanna Carboneli using the application

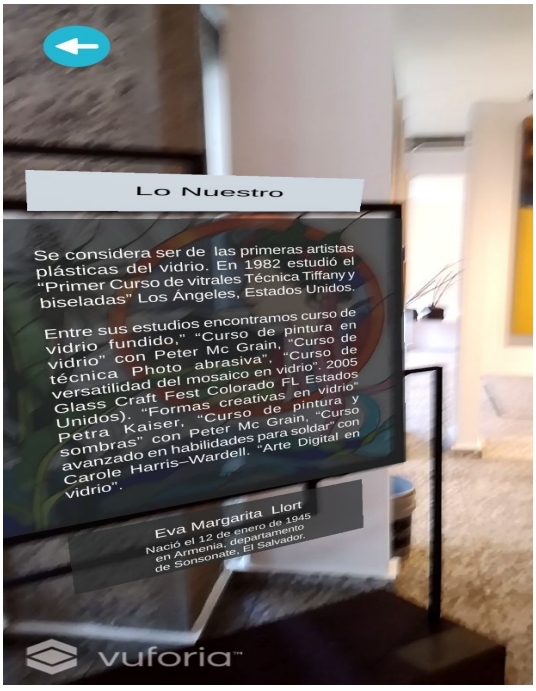

Fig. 8. Painting view Lo nuestro by Eva Margarita Llort de sade using the application

help the art gallery to improve the interactive experience of visitors in its exhibition halls; expanding and enhancing the visits of this cultural site. It also provides the option of virtual tours for people who cannot physically go to the facilities, giving them the option of getting to know the catalog of works, as shown in Fig. 9. The user experience was measured according to observation and a questionnaire conducted to a group of students within the facilities of the Universidad Don Bosco. In the case of quantitative data, two multiple-choice questions were asked regarding the following aspects:

1) Personal appreciation on the application of VR.
2) What is your appreciation of the 2D and 3D design of the scenes?

Each of them was measured by the evaluation scale; Deficient, Acceptable and Excellent.

A questionnaire of 2 questions was elaborated, which was passed on a sample of 26 users who participated. According to the results obtained, it can be seen which aspects should be reconsidered to improve the content of the application and future versions. We also present the results of the questionnaire

Fig. 9. View of paintings from virtual tour

by means of two graphs. For future versions, we plan to capture data that will provide more information and thus, make possible significant changes in our VR and AR application in different scenarios.

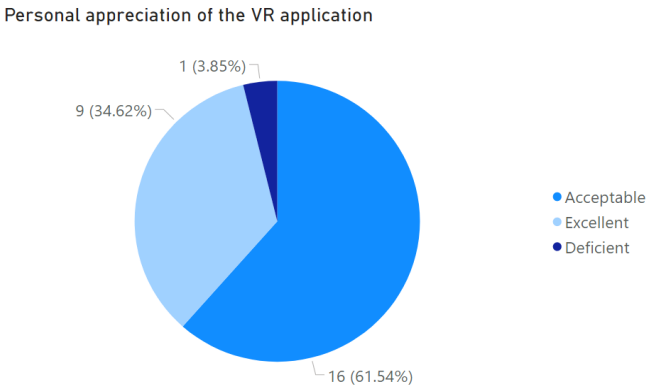

Fig. 10. Question 1 results.

In Table I, we present the results of our observation of users when using our application.

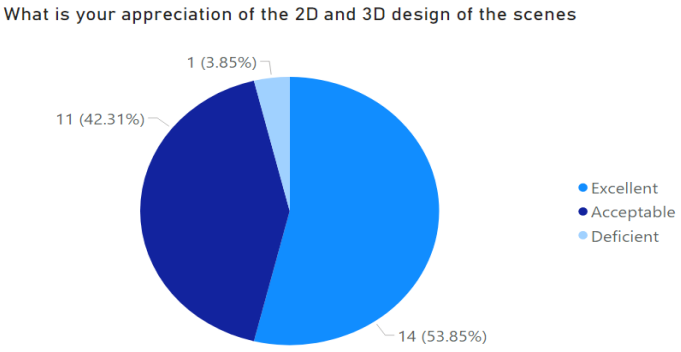

Fig. 11. Question 2 results.

TABLE I
REMARKS MADE TO USERS

Age ranges	**criteria for observation**	
	usability	***content***
18-25 years	They were able to manipulate all the scenes presented in the VR application. In this way they were able to walk through the entire art gallery	The young people showed interest in the VR application to be able to tour the art gallery
25 years or more	Like the previous group, they focused on going through the scenes, although some were more focused on seeing every single detail inside the rooms, so they did not go through all the available scenes.	This group of people found the application very interesting to see the various exhibition rooms, as they observed the works exhibited in each of them.

[a]summary table of observations made to users when using the application.

V. Conclusions and Perspectives

In this work a web platform was designed and implemented, which allows cultural entities to register and digitize their various works, sculptures or exhibition sites, regardless of the technique implemented in it. With this digitized information, we proceeded to communicate with a mobile application for the interactive presentation of the works and sculptures to the users.

With the experience gained in the implementation of this platform in a gallery, we argue that the web and mobile platform is feasible to be applied in other cultural areas such as museums, archaeological sites and interpretation centers. Our platform can provide visitors with a better experience in their tours within cultural environments, through VR and AR interactions.

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