

Augmented Reality for Mobile Devices in Support of Museums

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Resumen

Se describe el desarrollo, la implementación y evaluación de MUSUNAB-AR; una aplicación de realidad aumentada (AR) para dispositivos móviles Android. Se ha destinado especialmente para su uso en áreas de patrimonio y cultura específicamente para la sala de arqueología GUANE en la Universidad Autónoma de Bucaramanga-UNAB. Esta aplicación se basa en la georreferenciación y reconocimiento de imágenes que actúan como marcadores a partir del entorno real. Una vez que se asocian con la información virtual aparecen modelos 3D, 2D y vídeos.

El objetivo principal era crear una aplicación para dispositivos móviles en el ámbito del patrimonio y la cultura, donde se pudo evaluar la facilidad de uso, la eficacia y la eficiencia del uso de AR en los dispositivos móviles a través del Modelo de Calidad de Software para dispositivos Móviles.

Los resultados obtenidos por los usuarios, después de usar esta tecnología, y por medio de una encuesta, demostraron la conveniencia de la aplicación como una nueva herramienta para ser utilizada en los procesos de patrimonio y cultura.

Palabras Clave: *Dispositivos móviles inteligentes, Realidad aumentada, Metaio, Turismo, Museos.*

Abstract

We describe the development, implementation and evaluation of MUSUNAB-AR, an augmented reality (AR) application for Android mobile devices. It has been particularly intended to use in heritage and culture areas specifically for the living room archeology GUANE in the Universidad Autonoma de Bucaramanga-UNAB. This application is based on geo-referencing and image recognition from real environment images, to act as markers. Once they are associated with virtual information (3D models, 2D models and videos) the application allows interacting in real time.

The main objective was to create an application for mobile devices in the area of heritage and culture. In addition we evaluated the usability, effectiveness and

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efficiency of the use of AR on mobile devices through the Model Quality Mobile Software.

Results obtained by the users, after using this technology, and by questionnaires responses, demonstrated the application suitability as a new tool to be used in heritage and culture processes.

Keywords: *Smart mobile devices, Augmented reality, Metaio, Tourism, Museum.*

1. Introducción

Recently with the development of the new information technologies has changed the dynamics that takes place, allowing secure, modernize the way people live and interact in cultural heritage. The term cultural heritage is whatever is judged socially conservation regardless of utilitarian interest [1]. So speaking of the cultural heritage, we are referring to the concept of diffusion and transmission of its contents, therefore, has developed technology changes in the way they walk the cultural heritage, examples such as the Smithsonian Institution, found in Washington DC, seeks interaction of education to people through new technologies, for example, activities such as games, videos, etc. [2], another example is the application called Google Goggles its main function is to search for information through the image taken by the camera of the mobile device. The application allows identifying images, texts that are in the photo and show the user additional information [3]. According to the above, we can see how technology and cultural heritage work together to improve the user experience, for this reason, the aim of this paper is to analyze how new technologies can improve the experience of users in a museum, and how new technologies can spread awareness to users.

Much of this dynamism has been driven by mobile devices because the kind of technologies did not give full with augmented reality technology, while technology today has moved closer to the user's hand. The information technology (IT) has presented over the years. In the 80s, was generated digital heritage, with the advice of UNESCO, began to include images, documents, manuscripts, files, etc. libraries and museums, all function to keep the information [4].

In 1985, the Internet was already an established technology for communication and data transfer from one place to another. In the 90s, allowed hypermedia languages combine images, videos, audio and text to hypertext, interactivity and creativity allowing web pages [5]. The most direct application is in museums, presenting virtual museums, the

museums, contained website, bandwidth, multimedia technology available without the help of web browsers. Other museums began using virtual reality, as another means of interaction and learning [6]. The museums combined real objects with virtual information, and even simulations of scenarios that no longer exist [7] or deteriorated, that using mobile devices.

This dynamism accelerated with the advent of the Smartphone, since in 2012 the mobile landscape in Latin America, the market penetration was 5.6% and in tablets was 2.2%, while in the United States, the Smartphone reached 11.6% and 5.3% tablets. The extent of total Internet audience that Latin America is achieving 85.5%, this means that there is much room for growth in Internet access from mobile devices [8].

Mobile devices became popular and this occurred there was a huge advancement in technology, which means that the technology allowed open new perspectives for the user. In recent years it has been working with technologies like augmented reality (AR) for mobile devices (Smartphone), where AR is the evolution of virtual reality, it is the real-world interaction with the information found in a virtual world. AR worked with the interaction prototype technology as glasses, gloves, among others, until 2000 the mobile devices could be adapted to AR [9].

For this paper we will present an application to the Guane museum in the Universidad Autónoma de Bucaramanga - UNAB, which involve augmented reality techniques. The application allows user to show the basic information of where the museum and augmented reality applications made in seeking to show in more detail the museum without having a guide by and learn more about the culture Guane.

This article is distributed as follows: In section 2 we describe a review of the literature, where there is a clearer concept of the applications that have been working for cultural heritage using augmented reality. We then move on to describe the design and the implementation of the software prototype for the Guane museum in the Universidad Autónoma de Bucaramanga - UNAB in section 3, and in section 4 we will show the results on the sample of users who used the application. Finally, we summarize and disclose the importance of augmented reality in cultural heritage for today and why is an innovative technology.

2. Review of the Literature

Augmented reality is a technology that consists of superimposing virtual images on the reality that we see through a screen. But this technology has followed another better known concept in our society such as virtual reality, reality in a virtual world or virtual reality is the complete or

partial representation of a real or fictional environment, through the use of electronic media, which may include 3D graphics or images, also has the property of being or not being interactive and immersive [10], until Paul Milgram and Fumio Kishino defined in its so-called "virtuality continuum" in 1994 [11], see Fig. 1.



Fig. 1. Virtuality Continuum.

With the passage of time, augmented reality stopped using virtual reality technology and was conceptualized on computers, PDAs, mobile devices, which are currently having a high degree of applicability of Augmented Reality, as well as numerous options that have made this new technology closer. It just takes the integrated camera of the device and the screen to see the result of the overlap of virtual and real world.

Augmented reality offers several possibilities in the field of cultural heritage. In this initial way, the field in culture for the augmented reality is education. For example applications are dedicated to dynamic texts, traditional educational media such as books, among these applications are, Magic Book is a system by AR that can be seen as making life the pages of the book, the system allows users multi-scale collaboration, which means that allows multiple users to experience the same virtual environment [12]. Another similar application is a system that allows using the device camera to capture the education book.

Andalusia's Monuments and show on the screen, virtual information can be 2D or 3D images, video, audio, etc. [13], see Fig. 2.

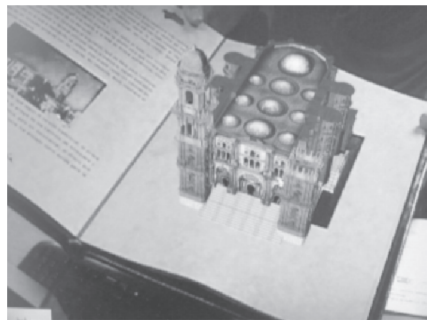


Fig. 2. The education book Andalusia's Monuments.

Then the topic of education was passed directly to the actual topic of museums and cultural heritage. In the cultural environment of a specific place called ARCHEOGUIDE system exists, this system allows to reconstruct places that no longer exist or are damaged. Among the projects that have been developed with this system, there are applications where you can rebuild the temple of Hera in Olympia [14], or you can provide help in one place, and based on the position and orientation rebuild ancient ruins everything by a device mobile and by AR [15]. Another way to show cultural heritage information using AR, patterns of images (QR) where the devices can recognize QR and show an image in specified information. For seventh week of science and technology of Andalusia was created a system where made known the advantages of AR in education and dissemination of heritage, the system could see in 3D images Egyptian chapel, or inside the human body as if the device were an X-ray machine [16]. Another application that works the concept of QR images are museums, through QR image can build and manage virtually exhibitions based on 3D models of the objects to be presented [17]. But there are other applications that closely resemble ARCHEOGUIDE, a system that enables virtual restoration of religious heritage objects using AR, the system detects that the camera has captured the device and the screen displays the missing object in reality [18], see Fig. 3.



Fig. 3. Reconstruction of a statue in a church.

In Spain for example, has developed an application, which seeks to support the implementation of knowledge of Molinar's historical heritage, and its application to the recovery of Andalucía's windmills [19]. Another application is in the field related Vilars, which is located in Arbeca, Lleida, where you can give out virtual information such as images and text on the site, this application also allows you to use the GPS indicated level where global positioning information

more Detailed [20], see Fig. 4. Another system similar to the reservoir is MARCH, this system aims, use augmented reality on mobile devices in specific applications in cultural heritage this system can display images of experts through the virtual world of a specific location [21]. In Sweetwater Creek State Park near Atlanta, is an application of AR development, where the user can see points of interest near the user, this system allows precise locations of a place and see the points of interest on the screen taking the active camera the mobile device [22].

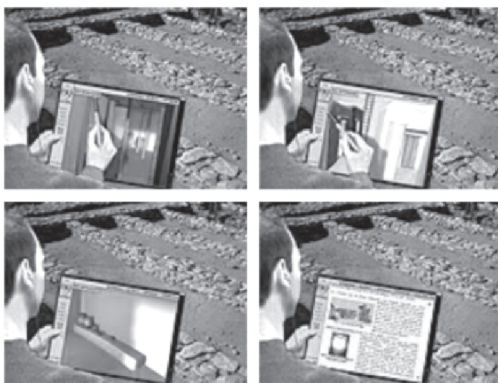


Fig. 4. Simulation: Reconstruction of housing and displays information.

3. Application Design

The application MUSUNAB-AR was created in the area of heritage and culture and ought to allow the creation of AR content channels and its visualization via a mobile device. The Universidad Autonoma de Bucaramanga-UNAB has a research group on Transdisciplinarity, culture and politics-TCP, whose researcher Gloria C. Oviedo has the experience and track record. In addition the university has on its premises a living room archeology GUANE located in Block D of the UNAB. This museum is an invaluable cultural richness so it is important to share and disclose both the university and the region and country.

According to data from StatCounter Global Stats 2013 [23] see Fig. 5, we can see that in Colombia the market for mobile devices is dominated by Android and iOS operating systems. The 31.24% of users use the Android operating system and 26.34% of users are from the Apple iOS operating system and only 42.41% use other operating systems. (Example Blackberry 19.99% and Symbian 7.08%)

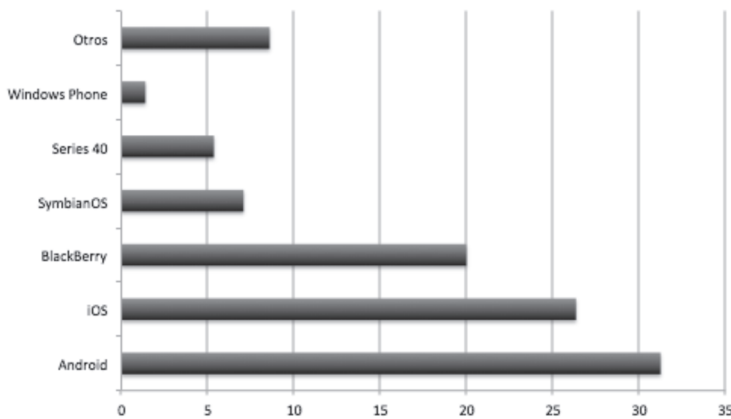


Fig. 5. Usage statistics for Smartphone operating systems in Colombia.

For this implementation, Native Android and Metaio Augmented Reality library was used. It is an augmented reality SDK (Software Development Kit) with proprietary license developed by Metaio GmbH for Android platform. Metaio enables developers to deploy applications free form; Metaio also differs from other technologies because it allows showing a room in 360 degrees, also Metaio has help forums for developers and various techniques for augmented reality display easily and dynamically to the end user.

The mobile device application (MUSUNAB-AR) recognize markers using the device camera and GPS, when the user use it, it shows virtual information overlapped to the real scene. The application allows users to interact easily with pieces and images found in the museum; also, the user does not to be in the museum to use it because there are two functionalities that works outside the museum. The application used the last technology, it means that Metaio Augmented Reality library contains the last functions that the developers can create and use it in different mobile devices, to create the best mobile applications for a variety of areas.

MUSUNAB-AR has seven functionalities that are divided in two parts, the first part is the functionalities that the user can use outside the museum, and the second part is the functionalities that the user can interact and learn inside the museum.

The first part is divide in two, the first one is the localization of the museum where the user can see a description and the real localization but also the distance between the museum and the user, see Fig. 6 (a). The

second one is the museum in 360 degrees where the user can see what it is inside the museum, and the user can move the device (up/down/right/left) to see all the space without using the touch screen. See Fig. 6 (b)



Fig. 6. (a) Sample Localization Museum GUANE and (b) Museum in 360 degrees.

The second part has five functionalities. Those functionalities are thinking to explain better the topics about the GUANE culture; one of them works with localization and the other four works with image or QR Code recognition.

For the localization inside the museum was thank for oriented the user and help them to know where are the pieces that have augmented reality, also to create an organization between the application and the museum. See Fig. 7.



Fig. 7. Localization of functionalities with augmented reality inside the Museum.

The next functionalities are using image recognition. The first image recognition functionality is called “Learn”, where through the camera can identify six masterpieces located in various parts of the room GUANE. When you focus the mobile devices with the piece, it will show a brief description. See Fig. 8.



Fig. 8. Description about a masterpiece Recognition with Augmented Reality.

The next functionality is called “Interact”. This functionality is different than the others because it utilized QR Code to show a 3D map. This Map represents the localization of the GUANES where they lived. This functionality also permits that the users can take photos of the map. See Fig. 9.

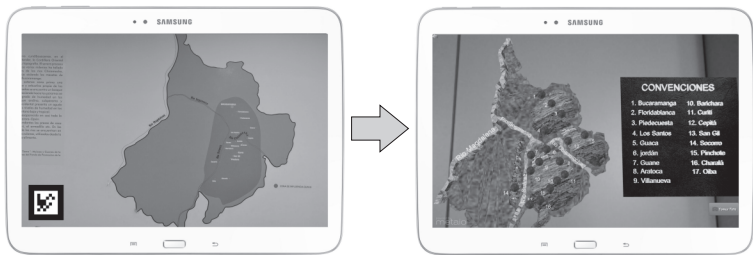


Fig. 9. 3D Map about QR code recognition with Augmented Reality.

The functionality called “Meet the Guanes”, is similar to the functionality "learn" but instead of an image shows a 2D animation. This animation talks about the Guanes culture and history about them. The animation is short but if the user is tired, he/she can rest and the continue where they were. The only thing is that they must not close the functionality. See Fig. 10.

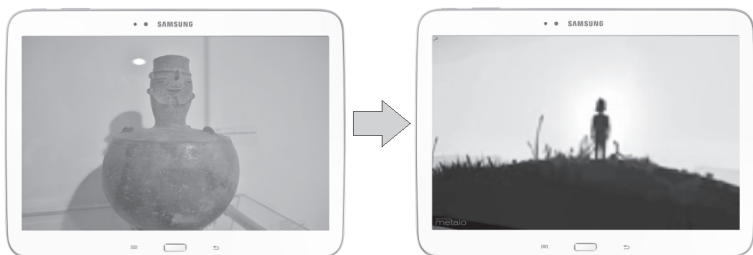


Fig. 10. Animation 2D about masterpiece recognition with Augmented Reality.

And the last one is called “Interactive video”, in this functionality the user must to focus the device in front of the wall that contains two columns with hieroglyphics and a billboard in the middle where it talks about the Guane culture. The result in augmented reality is a video with more information and more images about the customs of Guane culture. See Fig. 11.

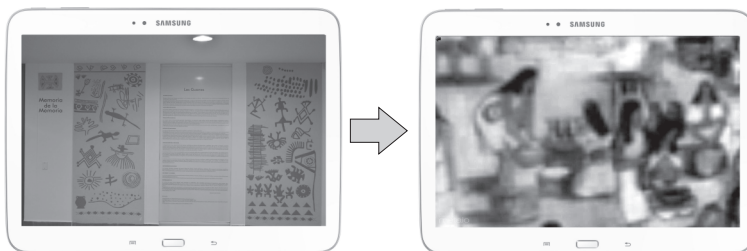


Fig. 11. Informative video of Guane about wall (image) recognition with Augmented Reality.

All this functionalities used the last technology in augmented reality for Android mobile devices. This technology implements a variety of information found in the living room archeology GUANE. But instead of a lot of reading they can see images, videos, or audio, and interact with theirs devices at any time without having any companion guide.

4. Evaluation

The assessment methodology for this test is the model of Mobile Software Quality. The use of this model for the development of mobile applications has the advantage that even in its basic version, it focuses on the characteristics that distinguish it today in mobile software, this means, that is intended to be used in the context of today's mobile devices. [24].

A survey was conducted to study the quality of the application view from end users, in the tasks related to application startup, using each element containing the application and the user behavior in the use augmented reality in and out of the GUANE museum. Thus, the survey aims to study three aspects important: (1) the usability of the interfaces (the interface design of the application), (2) efficiency (performance, battery efficiency) and (3) satisfaction of each user. The activity of the survey that was conducted in the following manner, first the participants had to use the application and once completed, they solve the survey from the point of view of each [25].

For the development of the survey included the collaboration of 23 volunteers. The participants were distributed as follows: five (5)

students and/or professionals in the Faculty of Engineering UNAB systems, six (6) members of the administrative part of the UNAB and twelve (12) student users of the education faculty, visual arts and Mechatronics.

To test the application, we worked with three mobile devices: Samsung Galaxy Tab3 10.1 (Android OS version 4.2.2), Samsung Galaxy S3 mini (Android OS version 4.1.2) and a Samsung Galaxy Note (Android OS version 4.0.3).

Question 1. The delay of the start of the application is:
The answers to this question are divided as follows:

- . Excellent (short time starting from 0 to 10 seconds)
- . Good (average boot time, between 10 to 15 seconds)
- . Regular (starting time is delayed longer, 15-30 seconds)
- . Poor (time is very long and the application loses interest, greater than 30 seconds).

The Fig. 12 shows the results of the first question, where 70% of respondents replied that the delay time of application startup is excellent, and 30% replied that is good, this suggests that the speed of the application is favorable for the end user.

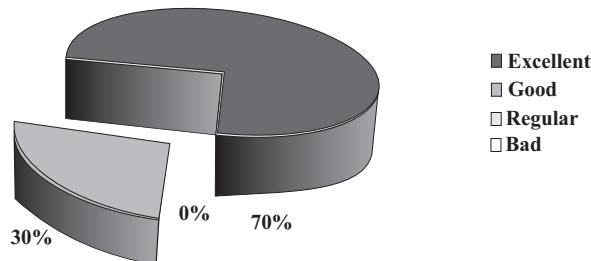


Fig. 12. Pie chart of question 1.

Question 2. Warning messages when starting the application are:
The answers to this question are divided as follows:

- . Excellent (shown when the application starts)
- . Good (shown at the beginning but it is annoying to the user)
- . Regular (shown at the start but the message is not understood)
- . Poor (no message is displayed).

The 78% of respondents answered that warning messages when starting the application are excellent, and the 22% replied that are good, these data suggest that users understand what is required of hardware (GPS, data network / WIFI) for operation of the application. See Fig. 13.

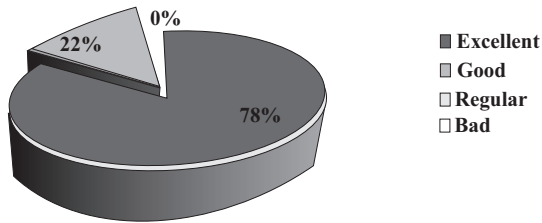


Fig. 13. Pie chart of question 2.

Question 3. The application design is simple and easy to use?

The Fig. 14 shows the results of the third question, which shows that 23 persons expressed satisfaction in the design of the application since it is simple and easy to use.

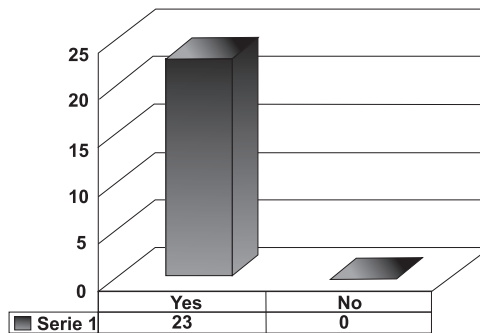


Fig. 14. Column chart of question 3.

Question 4. The way that the elements are distributed in the application is in sight.

The Fig. 15 depicts the results of the fourth question, where it is observed that 20 people found the distribution of objects in the ordered screen.

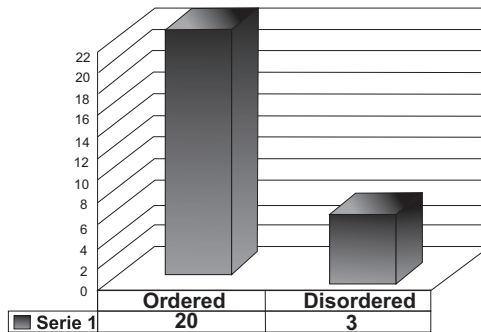


Fig. 15. Column chart of question 4.

Question 5. The instructions given before starting the Augmented Reality features are:

The Fig. 16 shows the results of the fifth question where the 96% of respondents replied that the instructions on the use of augmented reality features are clear making the execution of each one were success.

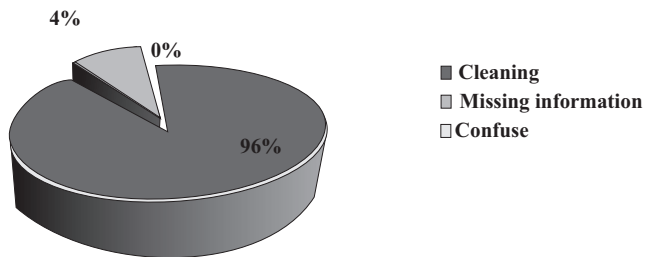


Fig. 16. Pie chart of question 5.

Question 6. The delay time to start the augmented reality functions is:
The answers to this question are divided as follows:

- . Excellent (short delay time between 0 to 10 seconds)
- . Good (average delay time between 10 to 15 seconds)
- . Regular (the delay is long, 15-30 seconds)
- . Poor (time is very long and the application loses interest, greater than 30 seconds).

The Fig. 17 shows the results of the sixth question, where it is noted that the 52% of respondents replied that the delay time for the start of the functions of augmented reality is good and 48% say it is excellent.

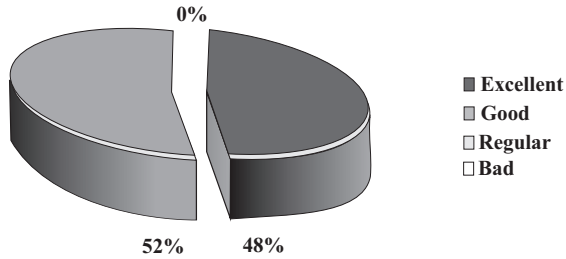


Fig. 17. Pie chart question 6.

Question 7. The augmented reality functions were to his liking and interesting to learn about the living room archeology GUANE?

In Fig. 18 the results of the seventh question were shown, the 23 people surveyed are interested in augmented reality for the living room archeology GUANE, also allows for greater upgrade and the interest in the participation of these technologies in the area of heritage and culture.

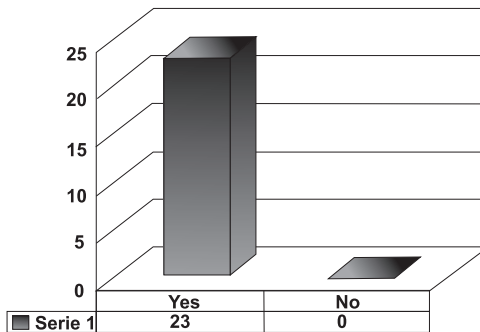


Fig. 18. Column chart of question 7.

Question 8. Since you started working with the application, the battery has decreased substantially?

The Fig. 19 shows the results of the eighth question where it is observed that most of the respondents answered that the battery consumption since the application starts until they closed was less than 5% of consumption.

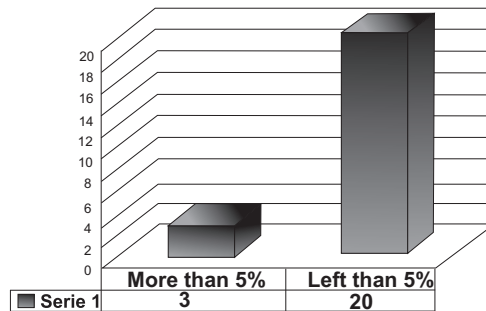


Fig. 19. Column chart of question 8.

Question 9. The application stopped at some point?

The Fig. 20 shows the results of the ninth question which, the 23 respondents replied that the application did not suffer any bug to automatically shut down while using.

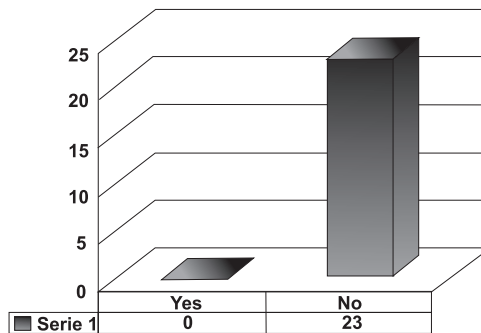


Fig.20. Column chart of question 9.

Question 10. An error is introduced into the process?

The Fig. 21 shows the results of question number 10, where 4 people surveyed found errors in the application or in the augmented reality functions, including errors encountered was the poor geospatial location of the device relative to the location of the points of augmented reality inside the museum; while the rest of the people (19 people) found no error during use of the application.

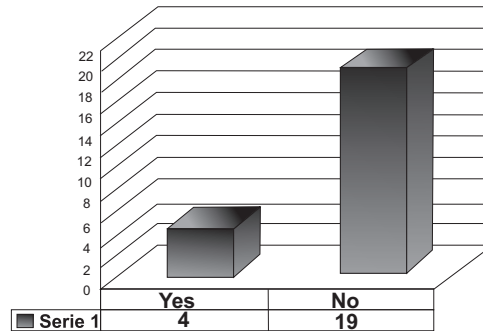


Fig. 21. Column chart of question 10.

Question 11. (Optional) Comments

For this question, 7 observations were made by respondents; There were identified the satisfaction, the efficiency and effectiveness of the application in a way subjective revealing what were the most common errors in enhanced functions, as well as the overall design of the application, but besides them actually users interest in augmented reality technology on other operating systems and for multiple versions of Android but not specific for the last generation Smartphone.

Some of the comments were:

- *“The application is great but could improve in terms of image resolution and design to make it more attractive. The videos were a very good tool but lost interest because they do not look good. It's a good job.”*
- *“I found it very interactive and interesting as it learns from Guane culture in a dynamic way, really well created the application”*

5. Conclusions

In relation to MUSUNAB-AR and the use of new technology on heritage and culture areas with mobile devices, other functionalities have been found over other applications from museums in other parts of the world such as: the possibility to display a room in 360 degrees without being there, the ability to interact with the objects and show more information in the scene, and others. These benefits were important to the viability of the study outdoors and indoors, helping to minimize the problem of stability in the scene of AR systems, based on optical recognition and geo-positioning techniques.

Related to the survey of the application, the results show significant information about the importance of augmented reality in the heritage and culture area, the user satisfaction, motivation to learn more of the living room archeology GUANE in UNAB and how to implement this technology in other operating systems.

Results suggest that the combination of augmented reality with the heritage and culture area, make the users feel more motivated. They interact with all the functionalities in augmented reality inside and outside the museum.

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