Value enhancement of the Artistic Heritage of Tierra del Fuego using Augmented Reality

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Abstract. The province of Tierra del Fuego developed tourism as one of its main industries since its beginnings, managing to establish well-established tourist circuits. With the increase of tourists received every year, the typical circuits are saturated. Through the use of new technologies, new tourist circuits can be promoted, contributing to the development of new sectors of the city and reducing the saturation of typical places. This work presents a mobile application with augmented reality capabilities that encourages the visit of the Artistic Heritage of Tierra del Fuego, trying to establish new tourist circuits. In turn, it compares the different techniques for the recognition of points of interest, applied on Artistic Heritage of Tierra del Fuego.

Keywords: tourism, smart tourist destinations, smart cities, augmented reality, artistic heritage, mobile apps, software engineering.

1 Introduction

This work is part of the project "Virtual and Augmented Reality, Big Data and Mobile Devices: Applications in Tourism" that since 2017 has been developed at the National University of Tierra del Fuego. The project seeks to reveal the uses that the tourism industry is making of these technologies individually or in combination, in order to propose alternatives for application in the field of Tierra del Fuego (TDF).

During the 2016-2017 season, Ushuaia – the main tourist city of TDF – received one third of its visitors through tourist cruises. Due to the way these boats operate, their passengers have a few hours to enjoy the city. As a result, a large number of people rush to make quick trips to the Tierra del Fuego National Park, a City Tour or simply buy and eat in the center of the city, generating saturation in those spaces.

Through the use of new technologies that complement the real world with the virtual one, new tourist circuits can be promoted. When generating other circuits, it contributes to the development of new sectors of the city, decreasing the saturation of typical places.

Combining the work done by the project "Survey and value enhancement of Artistic Heritage (busts, compositions, monoliths, plates, statues and masts) in public spaces of the city of Ushuaia, province of Tierra del Fuego, Antarctica and South Atlantic Islands, Argentine Republic", it is possible to generate an application that encourages tourists to know the Artistic Heritage. Complementing the application with augmented reality (AR) it will offer a more attractive and immersive experience [1], while promoting history and culture.

However, one of the challenges of augmented reality is to link and align reality with virtual information. There are many approaches: using physical markers, detecting geographical position, detecting the user's environment, among others. The following questions then arise: What approaches are currently feasible? What is the appropriate approach for this type of application? The present work seeks to explore the alternatives for the recognition of Artistic Heritage through the use of different techniques and tools, exposing the advantages and disadvantages of each one.

2 Augmented reality

Augmented reality employs computer vision, image processing and graphic techniques to fuse digital content in the real world. It also allows real-time interaction between the user, real objects and virtual objects.

To achieve this task, the user explores the environment through a screen that shows the real world, together with digital information superimposed. At the same time, a software makes constant monitoring to determine, in real time, the location and orientation of the camera and to react to the user's environment depending on the purpose of the application [2]. Specifically, for this work, it is interesting to be able to determine if the user is observing any of the locations where the Artistic Heritage is located.

There are different solutions to face this challenge. In the field of mobile devices, the most commonly used solutions can fall into two categories: AR based on markers and AR without markers. The border between both categories is diffuse, since the AR term itself is constantly evolving. Next, the chosen interpretation for each category will be defined, to then correctly frame the chosen technologies.

2.1 Augmented Reality based on markers

This category groups RA experiences that require the presence of a physical object to recognize the space over which virtual objects overlap.

A typical solution found in this category is to add a predefined pattern, easily detectable in the environment, and use image recognition techniques to detect it. This pattern is known as a marker.

Most markers are formed by black squares on a white background, forming two-dimensional bar codes. It is also possible to use colors or elaborate images, as long as their characteristics can recognize them quickly. An example of a widely used marker is the QR code.

Beacons are also considered within this category, although in clear decline. These are physical devices that emit a signal (Bluetooth, NFC, WiFi), which can be perceived by a smartphone. Through the use of an app that monitors and interprets the reception of the indicated signal, the device can react proactively and provide the user with information pertinent to the place where it is located.

AR based on markers has as its main advantage its simple implementation and the low use of device resources. Once the marker is recognized, it is easy to superimpose virtual objects in the desired position.

In contrast, the main disadvantage is the need to intervene in the real physical space to include markers. The materials and form in which it intervenes must be analyzed in each case in order to take the best advantage of the environment, considering the expected time of life and the conditions they must endure. Climatic erosion? Can people or animals damage them? How long should they last? Should they be easily modified?

2.2 Augmented Reality without markers

As its name implies, this category refers to the AR experiences that do not require physical markers to identify the real space over which the virtual object should be represented. There are several methods to achieve this task, being the most used the geographical positioning of the points of interest and the recognition of the environment through computer vision [3].

Typically, these methods use various sensors to determine the position and alignment with which virtual objects should be represented over the real world. The most used sensors are: GPS, accelerometer and gyroscope; The magnetometer, the light sensor and the proximity sensor are also used [4].

In parallel, points of interest (POI) must be identified. Under ideal conditions, they must be observable from different points of view and under different lighting conditions. This is called repeatability [5].

Of course, this continuous processing of information added to the constant collection of data from the sensors penalizes the efficiency and resources used [6]. Added to this, the monitoring of environmental conditions presents several challenges: dealing with large scenarios, variable lighting conditions, materials with low texture, reflective and transparent properties.

The introduction of ARCore[1] y ARKit[2] (official AR SDK of Android and iOS platforms respectively), contributed to improve the performance of AR experiences on mobile devices. They facilitate the development of applications with six levels of freedom; term used to describe the experiences of AR that respond to the rotation and

[1] https://developers.google.com/ar/discover/
[2] https://developer.apple.com/arkit/

position of the user as he travels. Additionally, they provide facility for the detection of different types of surfaces and mechanisms to react to different lighting situations.

However, due to their immature state, few devices on the market support them, limiting the set of users with access to these technologies. Currently both platforms publish compatible devices, being a very small group of devices in both of them.

3 Tools for the identification of points of interest

Understanding the available methods for the implementation of AR and, having as an objective the recognition of POI on the Artistic Heritage of TDF, tests were carried out with different tools.

The team decided to narrow the set of tools to those that address the problem using physical markers, computer vision and geographical position.

3.1 Considerations

When selecting and evaluating the tools, those that were open source and / or that provide some form of free use were prioritized. Additionally, they must allow multiplatform development. In this sense, due to the team's previous experience, solutions aimed at hybrid and interpreted development for mobile devices were sought, specifically Cordova / PhoneGap and React Native.

In spite of the above, it was considered of vital importance to evaluate the new SDK ARCore and ARKit, since these will be the bases for the future frameworks of development in AR. In addition, there is a library for React Native called ViroReact that allows to use both solutions under a common API, allowing to test the potential of the native SDK, without sacrificing the multiplatform objective.

On the other hand, despite its high cost license, it was also decided to include the Wikitude SDK as it is the only tool that allows detecting the points of interest with the three chosen methodologies. For its test the free version that overlaps watermarks was used.

3.2 Based on computer vision

About this method. It seeks to recognize a POI by evaluating frames to see a particular object, based on previous samples of the same - images.

Tools. For this approach, tests were conducted mainly with online services, highlighting IBM Watson Discovery[3] and Microsoft Azure Custom Vision[4].

[3] https://www.ibm.com/watson/services/discovery/
[4] https://www.customvision.ai/

Among the online services, the Azure platform was chosen because it has an interesting addition: the ability to export the learning of the AI to the native formats TensorFlow[5] (Android) and Core ML[6] (iOS), allowing offline recognition. Although this feature has not been tested, it is an important plus since the potential users of the application might not have access to the Internet.

Additionally, both Wikitude and ViroReact – and by transition ARCore and ARKit – allow this type of recognition.

Conclusions. This methodology is seriously affected by real-world variability. The artistic patrimonies are outdoors, severely affected by natural light and weather conditions. To achieve a reasonable result you need to use a large number of sample images, trying to contemplate different times of the year and points of view, affecting the user's storage space. Finally, the distance with which these photographs are taken will influence the minimum and maximum distance that the user needs to maintain with the artistic heritage to see the virtual information.

On the other hand, the use of online services is conditioned by internet access and connection speed. You must select the frames, upload them and wait for the answer. This could be solved by requiring the user to manually activate the recognition, but it impairs the feeling of immersion. In this sense, offline solutions are the best prepared, although they are equally affected by the variability of the environment.

Therefore, it is considered that this approach is not useful for this project, or for anyone who has similar conditions in the environment.

3.3 Based on physical markers

About this method. It uses physical markers with ideal characteristics for its recognition, facilitating its rapid recognition and reducing the use of resources.

Tools. The number of tools that support this type of AR is quite broad, making it difficult to make a selection. Without forgetting to highlight argon.js, the one that gave the best performance and flexibility was AR.js, in its version combined with A-frame. These combined javascript libraries achieve an incredible speed when detecting bookmarks, while also offering the possibility of taking this experience to the web. On the other hand, both ViroReact and Wikitude solve this approach.

Conclusions. Due to the presence of the physical marker, the variability of the natural environment presented by the previous problem is solved. Although climate and luminosity affect these markers, their characteristics make it easier to recognize the desired pattern.

[5] https://www.tensorflow.org/mobile/android_build

[6] https://developer.apple.com/machine-learning/

Of course, this solution requires intervening all the spaces where you want to have the experience and the maintenance of them. The size of the markers directly influences the distance required to recognize the marker.

Regarding the user experience, it can be criticized that it reduces immersion by having to focus on a particular marker, which may not be on the artistic heritage. Also, if there were a large number of people trying to scan the marker, it would generate an unpleasant situation for the tourist and the place.

3.4 Based on geographical position (GPS)

About this method. Knowing the user's position, the direction where he is pointing and the position of the POI, the distance between them can be calculated. If there is a safe distance when focusing, the virtual information is displayed.

Tools. From the survey conducted by the team, the only tool that offers this type of experience explicitly is Wikitude. However, there are libraries that allow conversions between the GPS coordinate system and the ECEF - Cartesian coordinate system, which allows to represent the field of vision observed by the user through his camera. Because of these libraries, this approach could be carried out using ViroReact.

Wikitude provides the best and simplest development experience, while the solution with ViroReact, has some flaws in the refreshment of the marker when the user is in motion.

Conclusions. Although the lack of tools is not very encouraging, this approach seems to be appropriate for situations where the point of interest is outdoors, as in this case. Knowing the distance between the user and the place, it can be manipulated with precision the correct moment to show the virtual object. In addition, the position is constant and is not affected by weather conditions or brightness, including being able to operate at night.

As a disadvantage, it is difficult to show the virtual element in the desired position. The GPS usually have a margin of error in meters, distorting (in the area of vision of the camera) the desired location of the virtual object.

4 Recognition of the Artistic Heritage of TDF

Based on the data provided by the project "Survey and value of the Artistic Heritage (busts, compositions, monoliths, plates, statues and masts) in public spaces of the city of Ushuaia, province of TDF, Antarctica and South Atlantic Islands, República Argentina", a mobile application was designed that combines this information with cutting edge technological aspects, to value the artistic heritage of TDF; seeking to encourage visits to the different POIs and disclose what they represent.

4.1 Mobile application design

Although the focus of this work is to compare the different AR tools to recognize the Artistic Heritage, a complete mobile experience was designed taking into account the previously mentioned objectives.

The mobile application was raised in a simplistic way, inviting users to discover the historical heritage by topic, searching directly on a map or accessing a filterable list of them.

Each point of interest can be marked as favorite, allowing to build a tour based on personal preferences. Each artistic heritage has an extended file where all the information about it can be seen.

Also, users will be able to make comments and rate each place, achieving a better interaction between them, which favors disclosure. In the future, the scores could be analyzed to detect patrimonies that need some kind of intervention, for example a settlement of the place.

Finally, the app offers a last alternative to know the POI, through augmented reality. The user will be able to access a mode where the camera will identify an artistic heritage. The initial objective is to show a virtual indicator that encourages the user to touch it to finally access the heritage file.

4.2 POI detection tools applied to Artistic Heritage

Of the totality of functions enunciated in the previous section, this work focuses on the last one, performing a technical test that allows to evaluate the advantages and disadvantages of the tools mentioned in section 3 for the recognition of the artistic heritage of TDF.

For this purpose, a mobile application was developed as a technical demonstration, focusing identification on three artistic heritage: the ARA Guaraní plaza, the monument to the Fallen in Malvinas and the monolith of the ARA General Belgrano.

For the test, only solutions based on physical markers and geographic positioning were used for the reasons explained in section 3.

Fig. 1. From left to right: the ARA Guaraní plaza, the monument to the Fallen in Malvinas and the monolith of the ARA General Belgrano.

Physical markers. To check the performance of the tools, a 12x12 cm marker was printed representing each Artistic Heritage. Then, the recognition was implemented with each technology, to finally test them in the same device and environment, being able to establish the following comparisons:

Table 1. Comparison of the experience with each tool.

Tool	Max. Distance	Detection in slight movement	Perceived speed
AR.js	130 cm	Yes. Very good	Excellent
ViroReact	80 cm	No	Regular
Wikitude	60 cm	Yes. Good	Very good

As an extra data, ViroReact performs a scan of the environment allowing to keep the object in the position where it was located, avoiding to recognize it again. This was clearly seen when making a 360 turn and visualizing the virtual object in its place as if it had always been there.

GPS. With each tool, a screen was implemented using the user's position and the coordinates of the POI, plus a fourth point a few meters from the ARA Gral. Belgrano monolith, exemplifying the visualization of nearby POIs.

Using Wikitude it was easy to develop this solution, since it has integrated this functionality. On the other hand, as mentioned above, a customized solution was developed using ViroReact and libraries to convert GPS coordinates to Cartesian coordinates and to manage user positioning.

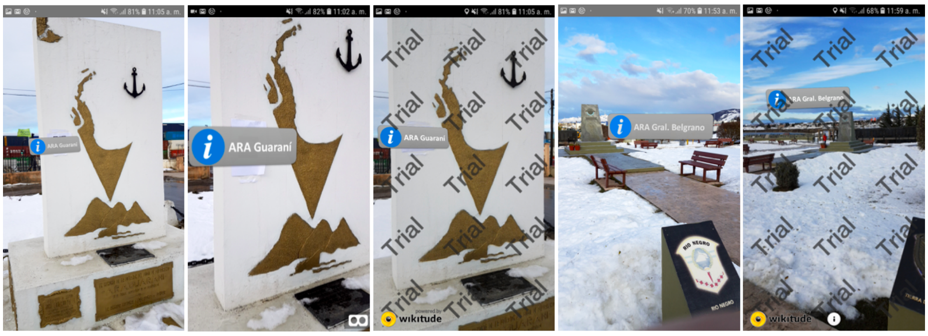

Fig. 2. From left to right: ViroReact, AR.js and Wikitude (Markers); ViroReact and Wikitude (geographical positioning).

Both tools allowed to position the virtual object with relative precision, being affected by the margin of error of the GPS of the device. Virtual objects moved slightly when the user moved but a comfortable experience was achieved. With both tools it was easy to adjust the altitude of the virtual object and the size relative to user's position.

As with physical markers, ViroReact benefits from scanning the environment, allowing to maintain the position of virtual objects when they leave the focus of the camera.

5 Conclusions

Taking into account the strengths and weaknesses of each approach and the tools available, it can be concluded that the method based on geographical position offers the greatest benefits for the detection of the Artistic Heritage of TDF. This is mainly due to the fact that it is not affected by weather or light conditions. However, the high license cost of Wikitude and the limited support of ViroReact devices can be a problem.

Considering that the designed application uses RA as a means of highlighting, allowing various mechanisms to make contact and knowledge of the Artistic Heritage, it is proposed to use a mixed approach, where physical markers can be combined with geographical positioning. A base experience can be offered using AR.js, for its performance and support of various devices, along with physical markers located in the most relevant POIs. In this way, all users will be able to enjoy the AR without being restricted by the device they have, while also probing the interest for the Artistic Heritage in the visualization of it through AR.

Then, in the same application, if it is detected that the device has support for ARCore or ARKit, it will be possible to expand the experience through geographic positioning. Users with this ability will be able to use AR to visualize all the points of interest, not only those that have a physical marker.

The closing of the experience, with the complete development of the application, its implementation and the analysis of the benefit achieved remain pending.

As an addition, with the metadata generated by the application, a system could be designed that learns from the user's behavior, punctuation and opinion, for identification of carelessness of the artistic heritage, launching campaigns to raise awareness about any of them in particular or take advantage of the popularity of some of them to enhance tourist circuits.

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