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Motiv-ARCHE: an augmented reality application to co-create cultural heritage resources with teenagers

1. Introduction

Traditionally, the primary objective of a museum was to gather, study and preserve collections, and to put them on (do-not-touch) display for the public. Museums nowadays, however, are more concerned about how to make their collections and exhibitions accessible and hands-on, how to attract visitors and how to provide a forum for discussing, developing and encouraging intercultural dialogue and learning. This means that museums need to take into account their visitors' experiences as well as their underlying motivation for going to the exhibitions in the first place (Dindler, Christian, Iversen 2009).

A survey of museums carried out by the European ORION project (Salgado *et al.* 2005) shows that 35% are displaying objects in 3D via technologies such as Augmented Reality (AR), as this allows them (in an attempt to attract visitors) to present their collections in an exciting, dynamic manner. Furthermore, Wojciechowski *et al.* (2004) noted that, for museums who do not have enough space to exhibit their collections, AR provides a perfect solution because they can show them virtually. However, Wojciechowski mentions two main difficulties with this. First, museums found the AR technology used to create the 3D models of the artifacts difficult to use and, second, the museum staff themselves, rather than experts in informatic technologies, had to set up the exhibitions.

On the other hand, a visitor's museum experience can vary depending on factors such as personal expectations, preferences and interests (Falk 2009). Falk defines five motivational categories: explorers, facilitators, experience seekers,

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professional/hobbyist, and rechargers, with which to identify the type of visitor and their individual characteristics. Each category defines the museum visitors, explorers are interested in the museum's content expecting something interesting, facilitators are focused on enabling the learning experience with others, experience seekers are motivated to visit the heritage sites because they perceive it as an important place, professional/hobbylist are interested in topics related to their passions or profession and rechargers want a spiritual and/or restorative experience. Depending in the category, museums can understand motivations and learning of the visitors based on their characteristics with different detail.

In the case of teenager visitors, museums cannot generate the same content they would for other visitors because the teenagers of today have very different beliefs and behaviors (Napoli, Ewing 2000), therefore they do not learn in the same way (Garris *et al.* 2002) becoming a passive user in the decisions. Tzibazi's research (Tzibazi 2013) shows that museums do not adapt their content for teenagers (aged 13-19) who are thus excluded as an audience group. This results in a lack of interest in the exhibitions on their part and makes them feel that museums are not important places. However, Tzibazi does mention that if museums generate an environment where teenagers can participate as co-creators, they will be more involved and motivated because they feel like important and valued visitors to the museum.

Implementing AR in learning environments, compared to mere on-site learning, could generate more learner interest, because it allows access to mechanisms with which to explore the real world through virtual objects such as texts, videos and pictures (Dede 2009).

After considering some of the characteristics and issues mentioned above, using AR technology we developed a prototype called Motiv-ARCHE which allows learners to co-create their own augmented Cultural Heritage (CH) content and which we will describe in the following sections of this paper.

In Section 2 the use of AR technology in CH places, such as museums and archaeological parks, the different AR technologies that these kinds of places generally use and the aspects that are important to consider when developing AR applications are discussed. Next, Section 3 describes the characteristics and functionalities of the Motiv-ARCHE application and then Section 4 outlines the conclusions and discusses future work concerning aspects that can improve the application's functionalities, and the contribution it can make to museums and their visitors.

2. AR technology in museums

Azuma (1997) defines AR as a system that combines virtual objects in the real or physical world, executed in real time and allowing the user to interact with them.

In educational environments, for example museums or archaeological parks, AR technology allows users to extend their learning process in an interactive way that generates productive and enjoyable environments related to cultural heritage (Lee 2012). AR technology has the potential of transform ways of learning about our world because the computer-generated content provides real sensations connected to the virtual and physical elements (Julier *et al.* 2016) and generates alternatives in the navigation, interaction and orientation in museums which host CH collections (Angelopoulou *et al.* 2012).

A recent survey has shown that there are two ways to track and register content with AR (Bekele *et al.* 2018). The first technique (marker-based tracking) uses physical sensors and in CH applications is usually achieved by a camera using markers or targets such as barcodes or infrared sensors. Most of these trackers are used in indoor environments because they require good lighting conditions; something that can be controlled by the users. In outdoor environments, this technique is not generally used because the environmental conditions could affect the functionality of the AR applications (Angelopoulou *et al.* 2012; Azuma 2016). The second technique (marker-less tracking) tracks points of interest (POI), where it merges digital data with real world inputs registered to a physical space (latitude/longitude) and AR applications augment this data using the device's GPS sensor. The digital data is augmented when the distance is short between location of the digital data (latitude/longitude) and the location obtained with the GPS sensor of the device.

The differences between these two techniques are that marker-less can recognize the geometrical features of an object, such as the edges and corners, or use the geographical position of the mobile device. Usually, this technique is used in outdoor environments (archaeological sites or landscapes) because recognition depends on the object or the geographical position and this is not affected by the external environment. That said, this technique can also be used in indoor environments, but this is not always feasible and is more prone to failure in conditions that require precision.

3. Motiv-ARCHE application

Motiv-ARCHE is a mobile and web application that works in educational environments and focuses on improving teenage motivation by allowing them to interact with CH elements such as masterpieces, sculptures, buildings, etc., using AR technology to create CH content in AR. The application allows the user to attach different kind of AR content such as audios, images, videos, 3D models without having to be an expert in computer sciences.

In the mobile application, the user can augment the content assigned by the users based on the image tracking and the position of the user's mobile device.

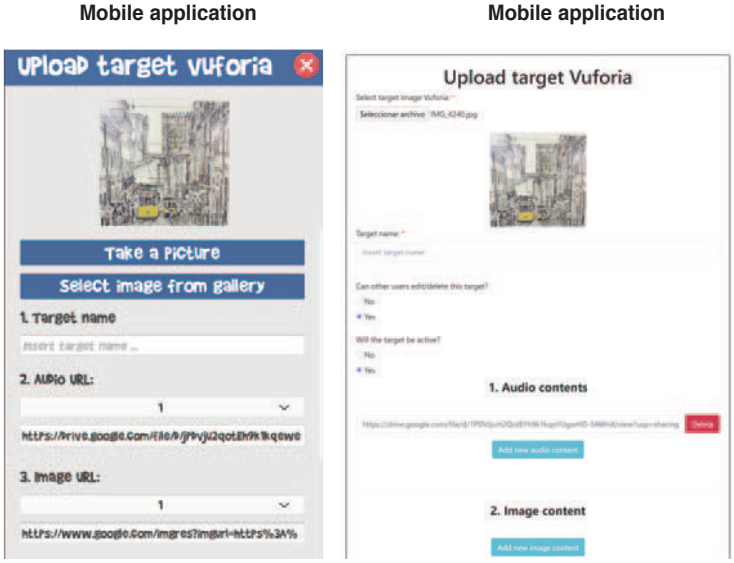

Fig 1. Upload target Vuforia.

This application was developed on the platforms Vuforia and Unity to augment content using marker-based tracking and marker-less tracking techniques.

Additionally, the web application (https://motivarch.online) stores the content to be augmented, i.e., the image that the application will use to show the AR content and relevant information. The registered users can add and/or obtain information about the different targets and POIs such as name, number of recognitions targets, status, content that is attached to each CH element, etc. The following subsections will explain the functionalities of the web and mobile application in greater detail.

3.1. Add and update target to Vuforia

The options *add* and *update target* in Vuforia allow the user to add or update a target in the Vuforia database. For that, the web and mobile application requests information such as: the image target that the mobile application will use to augment the content, the name (which must be unique) and the URL of the content that the user wants to augment (audio, image, video, 3D model and/or a website). Fig. 1 shows the two options where the user can add or update a target. The left column shows the mobile application where the user can select the target image by taking a picture with their camera or selecting an image from the gallery. The right column shows the web application, where the user only can add the target by selecting it from a file.

Fig. 2. Different formats of content to augment: a) audio; b) image; c) video; d) 3D model; e) website.

3.2. Scan a target

This function is only available in the mobile application where the user can augment the content of the targets registered in the Vuforia database. In this case, the user only scans the target (an object, a building, a masterpiece or whatever they wish to use) and the application will show the different resources that the user wants to augment (NB: these resources depend on the URL content attached to the target). Fig. 2 shows an example of a target with all the possible types of resources attached (audio, image, video, 3D model and website) and the user selects which one they want to augment.

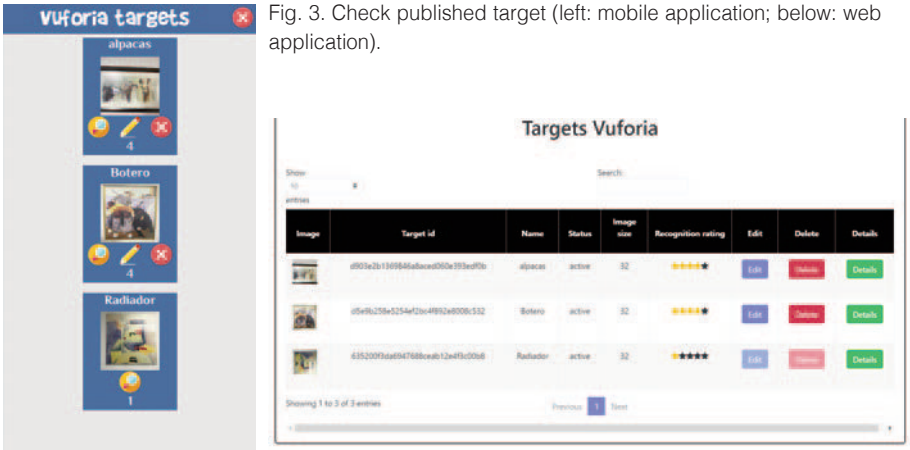

Fig. 3. Check published target (left: mobile application; below: web application).

3.3. Check published targets and target details

This function allows the user to check the targets that have already been published in the application. Fig. 3 (left) shows the function in the mobile application and the web application (right). The mobile application has the same options as the web, the magnifying glass icon shows the target in detail, the pencil icon allows to the user edit the target, and the close icon deletes the target.

When the user clicks on the option *Details*, the application displays the following information: date uploaded, name of the Vuforia cloud database, target name, tracking rating scale (0-5) that identifies if the target has a good recognition (5 = good recognition and 0 = poor recognition), the status of the target (active, inactive, processing), number of recognitions for the month, number of recognitions for the previous month, number of total recognitions, and the URL of the content to augment (fig. 4). This information is important for the user because they can then identify if the target can be updated with new content and if it is a good target to show the associated augmented content.

3.4. Check Vuforia Database summary

This function provides information on the usage of the Vuforia database. For instance, the name, active images, inactive images, failed images, images in processing, total recognitions of the previous and actual month and total recognitions. Fig. 5 shows an example of this characteristic. It is relevant because, depending on the Vuforia license plan selected, the application has a limit in the number of recognitions for the month.

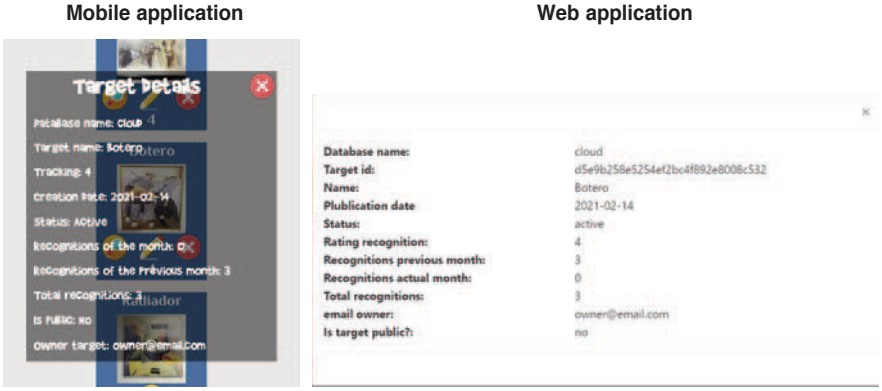

Fig. 4. Check target detail.

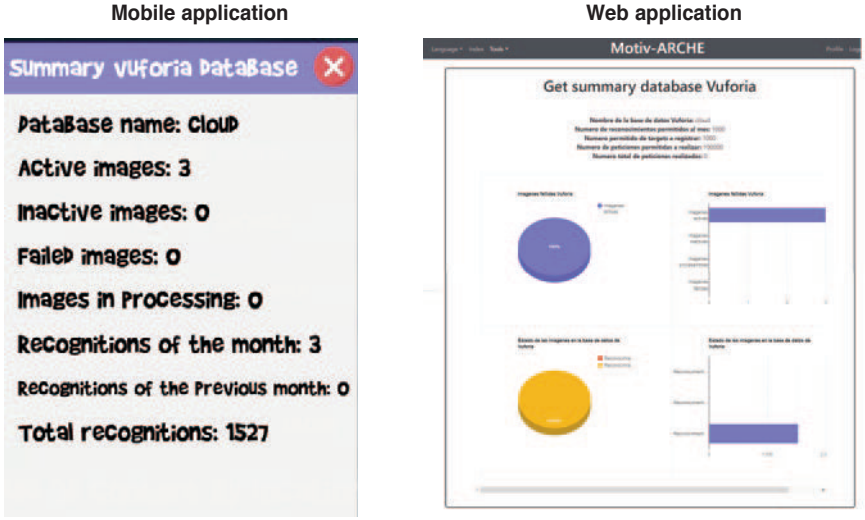

Fig. 5. Vuforia database summary.

3.5. Augment content based on mobile device position

Motiv-ARCHE uses the Google Maps API (fig. 6) to secure the information of the place selected by the user (latitude/longitude) and the application can register the POI that the user wants to augment CH content, based on the user's mobile device location. Fig. 6 shows the different tags of the application. If the first option is checked, the map will show all the POIs that Google Maps has, and the POI registered in the system; whereas if the second option is checked only the

Fig. 6. Google Maps API in Motiv-ARCHE.

Fig. 7. Add location.

POI created by the user will be displayed. The following options, for each POI created by the user, show if the POI can be updated and if it is active for other users, each color defines these two characteristics (editable/not editable and active/inactive), the green color defines active and editable, blue inactive and editable, yellow active and not editable and orange inactive and not editable. In addition, the system has an option where the user can define a route and the Google Maps API will shows the route the user needs to take. In this example (fig. 6), the POIs to visit are the "*Chorro de Quevedo*", the "*Museo del Oro*", the "*Plaza de Bolívar*" and the "*Museo Botero*".

The user can select any place or position on the map and the application will automatically open a new window with the information concerning that point (lat-

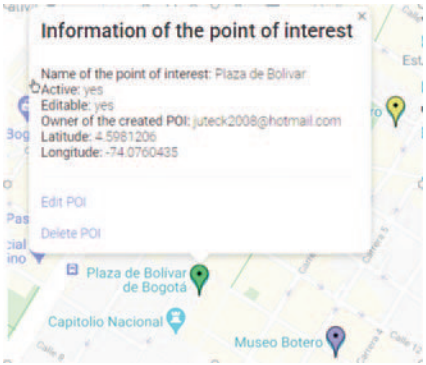

Fig. 8. Additional information.

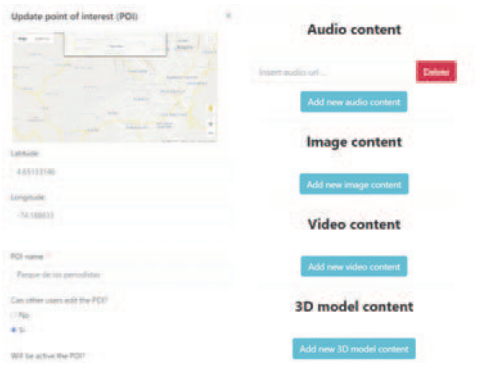

Fig. 9. *Edit POI* selected.

itude/longitude) that the mobile application will then use to augment the content. Fig. 7 shows what happens when the user selects a place or point on the map, i.e., it obtains the latitude/longitude, and the user must insert a name of the selected point (place) and the content to augment. For example, the POI "*Parque de los Periodistas"* was selected, the system obtains the latitude/longitude and the user can attach the content to augment (audio, image, video, 3D model and/or websites) to that POI.

When the user selects a specific POI, it shows additional information such as the name of the POI, email address, latitude/longitude and if the POI can be deleted/updated or not by other users (fig. 8).

When the user selects the *Edit POI* option (fig. 8), the application opens a new window with the information about the POI (fig. 9). The user can select a new POI on the map and/or edit the information (the content that they wants to augment, the POI's name, if other users can edit it, if it is active and its latitude/longitude).

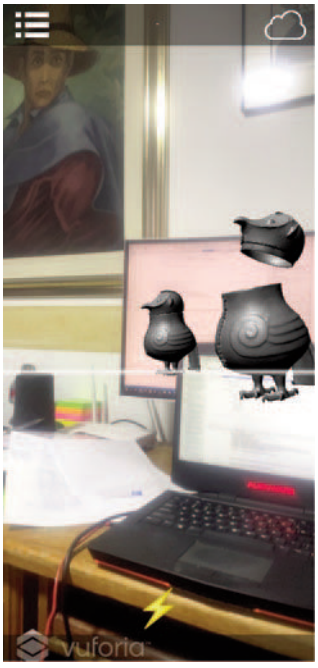

Fig. 10. Augmenting content based on location.

Once the user registers the POI in the mobile application if the user is close to it, the content will appear. Fig. 10 shows an example in the mobile application Motiv-ARCHE where a 3D model is augmented based on the position (latitude/longitude) of the mobile device and the POI registered in the web application.

4. Conclusions and future work

From the literature review concerning museums and exhibits, it could be useful for museums (or archaeological parks, among others) to make them more attractive to young people. The Motiv-ARCHE application allows users (in this case teenagers) to co-create AR CH content using the two techniques (GPS and image tracking) and increase teenages' interest in museums

The content that the user co-creates can be in different formats such as audios, images, videos 3D, models and/or websites without needing to be an expert in AR technology.

In the case of museum visitors using the Motiv-ARCHE mobile application, in an interactive way they are able to obtain more information about CH objects and places as they can select the content and format they like.

By using Motiv-ARCHE, and through AR technology, teenage users can become more involved in contributing information about CH objects and places in their towns. In other words, they can become active participants generating and complementing existing information with new content.

In future work, Motiv-ARCHE will implement an adaptation that aims to recommend CH places showing AR content based on the characteristics of the user, such as their personal interests and preferences. Additionally, this application will be tested with teenagers in real environments where they can use the system, co-create the AR content, and provide feedback on which aspects could be improved and if they would use it.

Abstract

This paper discusses some of the benefits of (and issues with) implementing Augmented Reality (AR) technology in museums to help teenage visitors learn about topics related to Cultural Heritage (CH). It describes a prototype application called "Motiv-ARCHE" designed to improve teenagers' motivation through employing AR in museums by allowing them to co-create the material to augment.
Keywords: *adaptive information, augmented reality, content co-creation, cultural heritage, motivation*

L'articolo discute alcuni dei benefici (e dei problemi) nell'implementazione di tecnologie di Realtà Aumentata nei musei, per incuriosire gli adolescenti a imparare temi relativi al patrimonio culturale. Si descrive il prototipo di una applicazione chiamata "Motiv-ARCHE" progettata per motivare gli adolescenti attraverso l'applicazione della realtà aumentata in musei, permettendo loro di co-creare il materiale da "aumentare".
Parole chiave: informazione adattabile, realtà aumentata, co-creazione del contenuto, patrimonio culturale, motivazione

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