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A PHYGITAL APPROACH TO CULTURAL HERITAGE: AUGMENTED REALITY AT REGALEIRA

UN ENFOQUE FIGITAL AL PATRIMONIO CULTURAL: LA REALIDAD AUMENTADA EN REGALEIRA

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Highlights:

- A strategy for boosting cultural heritage using augmented reality experiences does not only solve functional problems but greatly increases awareness and reputation.
- Technology can enhance cultural marketing and diversify the experiencing of cultural heritage sites; it also has the potential to attract new audiences.
- There are also challenges that are mainly related to technological solutions not fully developed yet.

Abstract:

In the last two decades, contemporary society has been conceptualized and discussed around the assumption that digital technologies are its most defining feature. Jean Baudrillard's take on the Fable of Borges suggests a replacement of the physical world by a virtual experiencing life, setting the tone for a pessimistic and somewhat fearful attitude towards technological development. On the verge of the dissemination of disruptive innovations that can be described under the "umbrella" of Internet of Things (IoT), we observe not a replacement, but a deep and complex intertwining of online and offline experiences, sketching the contours of what can become a phygital society. This alternative conceptualization of our contemporary society, combined with the possibilities of technological development, provides new opportunities for the expression and experiencing of culture, and also for the creative industries. In our research, we explore the impact of one augmented reality (AR) app designed for one of the landmarks of Portuguese cultural heritage, Quinta da Regaleira. We explore this unique case study using qualitative data collection techniques, aiming to discuss the positive and negative outcomes of this innovation, both for the dynamization of cultural heritage, and for visitors. The article provides useful information for heritage spaces that wish to follow this path. It describes the main steps to be taken in the production of content and provides examples of the narrative model that helps people to visit the space and obtain information, knowing stories relevant to the past and present of the cultural heritage. The objective is to clarify, finally, due to the research developed in the Quinta da Regaleira case study, what kind of stories and experiences can be narrated, the strengths of this application, its limitations, and paths for future investigations.

Keywords: phygital; cultural heritage; digital media; augmented reality (AR); AR apps

Resumen:

En las últimas dos décadas, la sociedad contemporánea ha conceptualizado y discutido en torno a la suposición de que las tecnologías digitales son su característica más definitoria. La versión de Jean Baudrillard sobre la Fable de Borges sugiere un reemplazo del mundo físico por una experiencia virtual de la vida, estableciendo el tono para una actitud pesimista y algo temerosa hacia el desarrollo tecnológico. Al borde de la diseminación de innovaciones disruptivas que se pueden describir bajo el "paraguas" de Internet of Things (IoT), observamos no un reemplazo, sino un entrecruzamiento profundo y complejo de experiencias en línea y fuera de línea, esbozando los contornos de lo que puede convertirse en una sociedad figital. Esta conceptualización alternativa de nuestra sociedad contemporánea, combinada con las posibilidades del desarrollo tecnológico, ofrece nuevas oportunidades para la expresión y la experiencia de la cultura, y también para las industrias creativas. En nuestra investigación, exploramos el impacto de una aplicación de realidad aumentada (RA) diseñada para uno de los hitos del patrimonio cultural portugués, Quinta da Regaleira. Exploramos este estudio de caso único utilizando técnicas de recopilación de datos cualitativas, con el objetivo de analizar los resultados positivos y negativos de esta innovación, tanto para la dinamización del patrimonio cultural como para los visitantes. El artículo proporciona información útil para los espacios del patrimonio que desean seguir este camino. Describe los pasos principales a seguir en la producción de contenido y proporciona ejemplos del modelo narrativo que ayuda a las personas a visitar el espacio y obtener información, conociendo historias relevantes

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pasadas y presentes del patrimonio cultural. El objetivo es aclarar, finalmente, debido a la investigación desarrollada en el caso de estudio Quinta da Regaleira, qué tipo de historias y experiencias se pueden narrar, las fuerzas de esta aplicación y sus posibles limitaciones, así como identificar caminos para futuras investigaciones.

Palabras clave: figital; patrimonio cultural; medios digitales; realidad aumentada (RA); aplicaciones de RA

1. Living in a phygital society

The phenomenon of the digital society can be presented as diverse, complex and penetrating, and can be discussed in different ways. In this sense, the problems of information, the direct and indirect issues related to it, as well as how adjacent phenomena such as data, action, difference and meaning, are all related to the expansion of the so-called information society (Ilharco, 2003). The information society, generated by the information revolution, showcases the fastest technological development in history. Today's most advanced societies base their initiatives on communication between people and information generated and managed by technologies, which are called information technologies. We can see important social, economic, political and environmental changes. According to Floridi (2003), the information revolution has profoundly changed the world. This same revolution has generated a wealth of new tools and methods, generating entirely new realities and making possible unprecedented phenomena and experiences, raising a wide range of conceptual issues and unique problems, thus opening up conceptual, research and of practices hitherto unimaginable (Floridi, 2003).

Information technologies have created a new reality, often referred to as virtual reality. Virtual reality, however, is as real as the realities that preceded it, claims (Castells, 2005) by stating that "reality as it is lived has always been virtual because it is always perceived through symbols that form the practice with a certain meaning that escapes its rigorous semantic definition". The present world is a dense space of technologically generated information. It differs from the world of a few decades ago mainly given the huge flow of data (which runs) between points distributed around the world, and can influence what we do. The "culture of simulation" (Turkle, 1997) offers the possibility of a "vision of a Multiple but Integrative Identity", elastic in the innumerable hypotheses of personalities and representations of the self, that can be created and lived as a kind of alter-ego, heteronyms or just fantasies, providing opportunities for self-expression (Turkle, 1997). For Turkle (1997), the real lives are distinguished from the virtual ones but both can coexist: an individual can have more than one personality at the same time. The relation of real-life and virtual life can be seen with different degrees of fusion, and may even be watertight, be antagonistic, or there may be a sequential line between one and the other. And in the construction of personalities, the representation of gender, type and even species opens up all possibilities. In virtual contexts generated by the computer, in networks or communities, thousands of users share experiences, feelings and sensations and even build relationships. They create a world in everything similar to the real, but with other possibilities, namely where there is greater flexibility of existences and other (smaller) consequences of actions. There may even be an invitation to a divorce of the real, which would represent a danger, a kind of alienation from existence for a virtual life that obeys other rules, the most common being an experience at two or more levels (real and virtual). In this sense, the information society is a paradigm of action and reflection of men/women in a world where we are confronted with various containers of information and meaning through the most varied screens. Technology, as a reordering of what is relevant and what counts and can make a difference in the life of each of us, as technological information, replaces the pre-technological reality.

Castells (2005) conceptualizes the network society as a digital layer that overlaps the physical world, in the same way that the one-to-one scale map requested by the king covers the whole territory in the Fable of Borges, presented by Baudrillard (1994) to explain his claim that the digital simulacra are replacing the real, up to a point when the real ceases to exist (the desert of the real). Castells (2005) agrees that the network society works with different criteria, as the space of fluxes is an alternative to the physical space and the timeless time is an alternative to cyclic time. In the network society, we are allowed multiple existences: we can sit in our bedroom at night, physically, and enjoy a multiplayer game online, interacting with people in different time zones in a flux of digital information. However, Castells (2005) disagrees with Baudrillard's (1994) vision of simulacra being false. His conceptualization of culture of real virtuality proposes that virtual experiences are as real as physical ones in the sense that they cause emotional and biological responses. In addition, they open up possibilities for experiencing, some of which may lead to further experiences in the physical world (e.g. boy and girl meet online, fall in love, meet offline, get married).

Currently, we live at a time of further technological transformation, as the internet is transitioning to a more pervasive, self-regulated and autonomous stage. One of the differentiating traits of this, the Internet of Things (IoT), is the embedding of technological features such as Wi-Fi connections and sensors in a wide array of objects, thus supporting machine-to-machine communication, constant data collection and reaction to such data, auto-regulation, self-learning and artificial intelligence (AI). The IoT is, therefore, an emergent and growing infrastructure of connected machines and objects that afford phygital experiences (Natal, Corcuera, Carruesco, & Alonso, 2017; Brumana, Oreni, Caspani, & Previtali, 2018). The concept of phygital is an alternative to conceptualizing the real and the virtual as separate layers, that may overlap (Turkle, 1997) or replace each other (Baudrillard, 1994). Rather, as Castells (2005) and Floridi (2003) suggest, the real and the virtual become entangled in a complex way, as we move through physical and virtual realities simultaneously, as actions on one of these layers affect the other, as they become facets of the same existence. The phygital experiencing the world is enhanced by the IoT, which combines physical items with digital interfaces and content, resulting in smart objects and smart environments, which adapt to our needs, preferences and routines responsively. The contemporary technological landscape intertwines

physical and digital in personalized and interactive experiences.

Milgram and Kishino (1994) further explored the relationship between physical and virtual, and proposed a reality-virtuality continuum, in which augmented reality (AR) is, along with augmented virtuality (AV), a mixed reality experience, more precisely combining real and virtual objects in a real environment, being able to register and align real and virtual objects with each other, and that runs interactively in three dimensions, in real-time. Thus, AR adds a layer of virtuality to real environments and objects, and although it usually addresses vision preferentially, it may encompass all senses. Thus, AR and AV are diverse technological possibilities of experiencing a phygital world. In this article, we look into how this different experiencing can be strategically applied to cultural heritage, adding layers of information and/or entertainment that enhance its experiencing and make it relevant and more attractive to different publics.

2. Enhancing cultural heritage with AR

Digital technologies have had a profound impact on tourism, and cultural heritage sites are no exception. In the last few years, the use of AR to enhance visits, mainly providing additional information, has been applied in several experiences throughout the world, enabled by the widespread and frequent use of smartphones and Wi-Fi networks (Jung, Chung & Leue, 2015). Applying AR to cultural heritage is interesting because it addresses several needs of cultural heritage sites and professionals, while at the same time is appealing to different publics of such sites. Concerning challenges of managing cultural heritage sites, AR enables: a) access and showcasing to vast collections, with detail and from different points of view, regardless of space limitations; b) exploration of artefacts while ensuring their preservation; c) simulated manipulation of artefacts; d) additional information about artefacts and context; and e) comparing artefacts, or placing them in scenarios. Concerning visitors, AR enables the monitoring levels of excitement and boredom of visitors, thus personalizing the visit, making it more interactive and engaging, supporting motivation to learn and active learning, and enhancing the attractiveness of the site (Damala & Stojanovic, 2012).

AR experiences in cultural heritage visits are always informative, and most of the times educative. They have great potential to support the experiencing of cultural heritage by the large public (and also by specific publics such as families and children), not only complementing current tools and practices such as maps, guides, visual content in exhibitions, but going beyond them. AR represents a qualitative leap in experience because of its responsiveness to context, of its potential for personalization, and also because of its potential for entertainment (Mortara et al., 2014).

The most common formats for cultural heritage sites AR experiences are: a) serious games (games designed for educational objectives which support learning in an engaging and fun way); b) virtual environments; c) prototypes, demonstrators and simulators (virtual collections); d) virtual museums; e) commercial historical games (games that simulate historical events in which users can partake); and f) mobile guides (Anderson et al., 2010; Ardissono, Kuflik, & Petrelli, 2012).

Research on cultural heritage AR experiences highlights a paradigmatic change from passively receiving information to actively learning, which is supported by co-creation of digital storytelling and personalization (Stricker, Pagani, & Zoellner, 2010; Mortara et al., 2014). This technology can support value-added experiences and services that offer location and time-based interactivity, entertainment and personalization (García-Crespo et al., 2009; Kounavis, Kasimati, & Zamani, 2012). AR added dynamic layers of meaning and experiences to the visit, combining contextual responsiveness with multimedia content. They can also include a social layer which affords the possibility of social interaction within personal networks and with other tourists (Cortimiglia, Ghezzi, & Renga, 2011; Barrile, Fotia, Bilotta, & De Carlo, 2019).

The main features that tourists find attractive in AR experiences are the thrill of trying out an innovative experience, the visual nature of AR, and the situational nature of AR, which affords adaptation to context and personalization. All these factors reinforce the perception of AR as useful and may favour destination choice (Puyuelo, Higón, Merino, & Contero, 2013; Chung, Han & Joun, 2015; Blanco-Pons, Carrión-Ruiz, Lerma, & Villaverde, 2019). Concerning satisfaction with AR experiences of cultural heritage visits, the most important factors are technological quality, quality of content and the personalization of the experience. These factors are predictive of the willingness to recommend AR experiences to others (Jung et al., 2015).

Although AR cultural heritage mobile apps are transitioning from experimental pilots to a commercial phase, the technology still has limitations to overcome. For instance, they can have an information overload effect on tourists, who may feel overwhelmed with the amount or pace of information, or find some information irrelevant (Kounavis et al., 2012). Simulating historical events in serious-games can raise ethical concerns regarding accurateness and violence, but virtual heritage projects can include some of the serious games-style goals and elements, thus entertaining visitors (Champion, 2016). In spite of these issues, "(...) AR has the potential to enhance tourists' experiences and make them exceptional" (Yovcheva, Buhalis, Gatzidis, & van Elzakker, 2014).

3. Methodology

In our empirical work, we set out to explore the advantages and disadvantages resulting from enhancing the experience of visiting cultural heritage sites with AR.

For that purpose, we selected an AR app of one landmark of the Portuguese cultural heritage, Quinta da Regaleira, which was launched in November 2017. This is the first AR app launched by a cultural heritage site in Portugal. Thus, we considered it appropriate as an exploratory single case study (Yin, 2017), and researched it using a qualitative method.

Our research design includes three stages. The first stage was of documental search and analysis, in order to collect the maximum of information possible about the features of Quinta da Regaleira's AR app, Regaleira 4.0, its development process and its goals. Our documental database includes 16 news pieces: four online news

pieces on general informative media, three online news pieces on economy or marketing media, seven online news pieces on tourism media, one TV news piece broadcasted during informative prime-time on a generalistic TV channel, and one report on a branding programme on a generalistic TV channel. All of these news pieces featured the launch of the app Regaleira 4.0.

The second stage included an in-depth interview to a relevant agent in the process, in order to gain more insight on Regaleira 4.0. We interviewed Luís Patrício, Director of CulturSintra Foundation, the entity that manages Quinta da Regaleira. Luís Patrício has been a member of the Board of Directors of CutlurSintra since 2013. Previously, he was vice-president of the CulturSintra administration department between 2005 and 2009, during which time he was a councilman at the Sintra City Council. During his administration, he made an important reshuffle in the role of cultural tourism in the region, with a growing focus on the dissemination of cultural heritage with the new information and communication technologies. He was present throughout the Regaleira 4.0 implementation process and is truly active on Sintra's and Quinta da Regaleira's cultural and touristic life, which makes him the best person to produce an overall analysis of the most important changes on this site's life since the app has been developed. We also interviewed Pedro Pereira, director of the agency "byAR - Augment your Reality", a company hired to develop the AR app.

Finally, in our third stage, we conducted non-participant observation, observing and registering field notes about visitants using Regaleira 4.0 during three day (April 12th, 19th and 25th). The goal of this stage was gathering information about the positive and negative points of Regaleira 4.0 for the visitors, about their experiencing of the AR visit. This stage was necessary not only to triangulate the data collected in the two previous stages, but also because the app, at the time of our research, did not collect any data about its users or usage that could help us assess this phygital experience.

Regarding data analysis, after a preliminary reading of the data, we defined categories related to the structure and content of a case study: a) problem, challenge or situation to address; b) action, solution or innovation developed by the agent, company or brand; c) outcomes of the action, solution or innovation implemented (distinguishing positive and negative outcomes); and d) lessons to be learned from this case study (Yin, 2017). Then, we coded the news pieces, our observation field notes and the interview transcript according to these categories, thus applying a qualitative content analysis (Miles, Huberman, & Saldaña, 2013). We applied evaluative content analyses to these data in order to produce a qualitative view of the results –real and expected– developed since the implementation of Regaleira 4.0. If our documental database was capable to produce a media point of view of Quinta da Regaleira's touristic adherence since the app was introduced, Luís Patrício's interview made it possible to analyse the effects of this app according to an official agent of Sintra's Cultural Council, and our non participant observation helped us understand the strengths and weaknesses of this AR experience for the visitors (Bardin, 2011). Also, the interview with Pedro Pereira from byAR allows us to obtain data regarding technological solutions for the application of AR to architectural heritage. The proposed case study methodology intends to observe the human-machine interaction with the new information and communication technologies and the technological immersion in the cultural heritage. The observation of reports carried in large communication vehicles, the use of new technologies and the interview with the relevant agent of the case study demonstrates the required methodology validation. The demonstration of the results obtained as well as the presentation of the positive and negative results support the methodological proposal. Finally, we present the lessons that can be learned from this case study at multidisciplinary points.

4. Quinta da Regaleira Case Study

4.1. Quinta da Regaleira

Quinta da Regaleira is an estate located near the historic center of Sintra, Portugal. It is classified as a World Heritage Site by UNESCO within the Cultural Landscape of Sintra (Fig. 1).

Figure 1: Overview of Quinta da Regaleira (©www.regaleira.pt).

The property consists of a romantic palace and chapel, and a luxurious park that features lakes, grottoes, wells, benches, fountains, and a vast array of exquisite constructions (Figs. 2, 3 and 4). The palace is also known as "The Palace of Monteiro the Millionaire", which is based on the nickname of its best known former owner, António Augusto Carvalho Monteiro. The land that is now Quinta da Regaleira had many owners over the years. It belonged to the Viscountess of Regaleira, a family of wealthy merchants from Porto, when it was sold in 1892 to Carvalho Monteiro for 25,000 réis. Monteiro was eager to build a bewildering place where he could collect symbols that reflected his interests and ideologies. With the assistance of the Italian architect Luigi Manini, he has recreated the 4-hectare estate.

In addition to other new features, it has enigmatic buildings that allegedly held symbols related to Alchemy, Masonry, the Knights Templar, and the Rosicrucians. The architecture Manini designed evoked Roman, Gothic, Renaissance, and Manueline styles. The construction of the current estate commenced in 1904 and much of it was completed by 1910. The estate was later sold in 1942 to Waldemar d'Orey, who used it as a private residence for his extensive family and have ordered repairs and restoration work for the property.

Figure 2: Portal of the Guardians (©www.regaleira.pt).

Figure 3: Fountain of Abundance (©www.regaleira.pt).

Figure 4: Waterfall lake (©www.regaleira.pt).

In 1987, the estate was sold, once again, to the Japanese Aoki Corporation and ceased to serve as a residence. The corporation kept the estate closed to the public for ten years, until it was acquired by the Sintra Town Council in 1997. Extensive restoration efforts were promptly initiated throughout the estate. It finally opened to the public in June 1998 and began hosting cultural events. In August of that same year, the Portuguese Ministry of Culture classified the estate as "public interest property". The Regaleira Palace will be the same name as the entire estate. The structure's façade is characterized by exuberantly Gothic pinnacles, gargoyles, capitals, and an impressive octagonal tower.

The palace contains five floors (a ground floor, three upper floors, and a basement). The ground floor consists of a series of hallways that all connect the living room, dining room, billiards room, balcony, some smaller rooms, and several stairways. In turn, the first upper floor contains bedrooms and a dressing room. The second upper floor contains Carvalho Monteiro's office, and the bedrooms of female servants. The third upper floor contains the ironing room and a smaller room with access to a terrace. Finally, the basement contains the male servants' bedrooms, the kitchen (which featured an elevator for lifting food to the ground floor), and storage rooms. Much of the 16187.4 m^2 (4 acres) of land in the surrounding estate consists of a densely treed park lined with myriad roads and footpaths. The woods are neatly arranged in the lower parts of the estate, but are left wild and disorganized in the upper parts, reflecting Carvalho Monteiro's belief in primitivism. Decorative, symbolic, and lively structures can be found throughout the park. The park also contains an extensive and enigmatic system of tunnels, which have multiple entry points that include: grottoes, the chapel, Waterfall Lake, and Leda's Cave, which lie beneath the Regaleira Tower. The Initiation Well connects to other tunnels via a series of underground walkways.

4.2. Problem

Quinta da Regaleira is among the main cultural heritage destinations in Portugal. In 2016, Foundation CulturSintra, the entity responsible for managing this site, reported over 1 million visitants. Offering an engaging and enriching visit to such a complex site –which is interesting historically, architectonically, symbolically, for its vegetation and botanic– and making it available to such a great amount of visitors, was a challenge. There are guided tours at Quinta da Regaleira, but the offer does not meet the demand. Also, CulturSintra desired to afford more interesting and engaging alternatives to those who were not able to enjoy (or afford) a guided tour, and who only had available paper maps and guides, and on-site signage.

The timing for developing the app came when Quinta da Regaleira was reaching a tipping point. It was working to its full capacity most of the year, and Luís Patrício claimed that it is not possible to expand further the number of daily guided tours or the size of the groups, without decreasing the quality of service. On the other hand, at Quinta da Regaleira, they observed that maps had little information, and that many visitors give up listening to audio-guides mid-visit, as this experience is not engaging enough, particularly for younger visitors (children and teenagers). Luís Patrício claimed that the main idea behind Regaleira 4.0 was making “Regaleira has jump from paper, from maps and guides, to an experience that we carry in our pockets and that interacts with us”. Thus, the main goal for developing Regaleira 4.0 was offering a richer and more interactive visiting experience to the current publics of the site.

Pedro Pereira informs that the Quinta da Regaleira project had as main objective to make the visit to the Quinta da Regaleira park more dynamic, making this visit richer in content and experience and that its main restriction was the non-physical intervention in the space.

Luís Patrício reiterates that “the Foundation has as mission promoting and publicising culture, and what drove us to create Regaleira 4.0 was thinking about how

we could do that, reaching more people, and in a more engaging way". Additionally, CulturSintra believed that the app would motivate some visitors to come back and enjoy other tours (mostly Portuguese visitors) –the app currently offers five different tours– and also contribute to attracting new publics (namely families with young children, for whom the visit might not be engaging enough).

4.3. Solution

In order to develop Regaleira 4.0 (Figs. 5, 6 and 7), CulturSintra Foundation created a partnership with technological companies –Made In Lisboa (MIL) and ByAr– and with a marketing agency –Laranja Mecânica. All of the four entities of the consortium invested in the development of this AR app, believing that concretising such an innovative and groundbreaking solution (in Portugal) for enhancing the experience of visiting cultural heritage would show the potential of such technology and solutions, and create demand.

Luís Patrício emphasized that "it is an unprecedented attraction in Portugal". Regaleira 4.0 is an AR app that only works on-site, depending on the geolocation of smartphones. Outside Quinta da Regaleira, the users of Regaleira 4.0 have access to text and multimedia information, but not to AR experiences. The app offers 5 different tours, with a total of 70 interactive experiences, 40 AR animations with 3D avatars, 30 videos with 3D agents and over 100 information entries using digital storytelling. It is available for free to iOS and Android, in Portuguese, English and Spanish. The app can be downloaded at the ticket office, and later used on-site without requiring internet connection or mobile data consumption. Also, free disposable headphones are offered at the ticket office to those who want to try out the app. Luís Patrício stressed that "the app enriches and teaches".

The AR experiences are enriching because they offer additional information about the different sites, their history and symbology, and some of them are also ludic (Figs. 8 and 9). They are also interactive because when a visitor approaches a place where an experience is available, the smartphone receives a notification signalling it, sent from beacons strategically placed throughout the cultural heritage site. These experiences are varied and diversified, ranging from objects and statues that come to life to explain details about themselves, to historic figures who narrate their connection to the place, to the observation of reconstitutions of religious and symbolic rituals.

Figure 5: Main screen of Regaleira 4.0, featuring the 5 tours available at Regaleira 4.0 app (source: Regaleira 4.0 print screen).

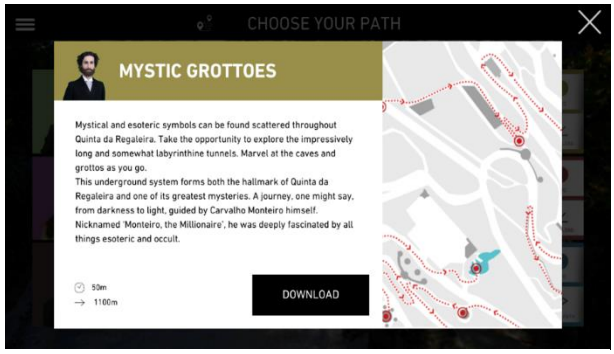

Figure 6: Example of informative entry: information about the "Mystic Grottes" (source: Regaleira 4.0 print screen).

Figure 7: Example of video with 3D agent: poet Luís de Camões explains the symbolism of the decorations and figures in a fountain (source: Regaleira 4.0 print screen).

Figure 8: Example of AR experience: a statue comes to life to explain her identity –it is a muse– and symbolism (source: Regaleira 4.0 print screen).

Figure 9: Example of AR experience: historic reconstitution of templar ceremony in the chapel (source: Regaleira 4.0 print screen).

Using AR technology and good content it was possible to fully achieve the project's objective, however, the use of this technology would imply starting from the placement of a set of boards with markers/content activators.

At the time of project development (2017) most of the existing AR frameworks offered the possibility of displaying content using markers (images), Global Positioning System (GPS) position, in some cases providing a technique called Simultaneous Localization and Mapping (SLAM) and in many rare cases through object recognition, says Pedro Pereira.

Since you could not have marker boards along the paths, you could not use the marker-based content activation technique. Nor could it use the GPS position since the accuracy of the technology in this park context could lead to activation of the contents in the wrong places. Using object recognition to activate content was also unthinkable as it would entail digitizing more than 70 interaction points within Quinta da Regaleira.

According to Pedro Pereira, the most appropriate solution for activating the content would be the use of the SLAM technique, however, this technique implies that the equipment is constantly mapping the environment and recalculating the user's position in relation to the content, meaning that in the case of a smartphone the battery would quickly be discharged.

After researching several commercial solutions, the byAR agency opted for the use of Vuforia and a technique similar to SLAM, which is called Instant Tracking and which does not require constant mapping of the environment. Instant Tracking consists of taking a photo of the environment and using this photo as a marker to activate AR content. For the user this process is completely automatic and imperceptible, as the only thing that is required of the user is to point the smartphone where you want the content to appear and tap the button to start content. Pedro Pereira says that the moment the user touches the button to start content, the system takes a picture and places the AR content on it. With Instant Tracking you do not need bookmarks as they are generated at the moment the content is activated.

Using Instant Tracking it was possible to add new content to Quinta da Regaleira's visit.

Since application would necessarily have to resort to the GPS position to tell the visitor where they are on the route and in the park, it was decided to use the GPS position also to alert when the visitor was near AR content. Using the GPS position and having the visitor previously selected a route, the system knows what content to display at each point in time. To ensure that the visitor points the smartphone to the right place, at the time the new content alert is launched, the transparent image of where the content is to be activated is also displayed on the screen. Using the GPS position of the visitor is then indicated that there is content in that place, appearing on the screen where the visitor should point the smartphone to activate the content, you can give an AR experience as good as having the markers in each location, says Pedro Pereira.

The project also used beacon technology to help improve GPS accuracy and because in certain locations of Quinta da Regaleira there is no GPS and Network signal. "Using this technology it was possible to activate content inside caves where the GPS signal is totally non-existent and where two points with content were very close, beacons helped to decide which content should be activated," said Pedro Pereira.

About the contents Luís Patrício said it is important that the app “did not resemble a boring history class”, but instead was “a rich and interactive experience, driving cultural heritage to the age of internet 4.0”. Actually, he described the need to conciliate the “historian” and “expert” perspective with the “marketing” perspective as one of the main challenges faced when deciding about the concept for the app and the user experience desired. The group of expert consultants insisted on historic and scientific rigour and accuracy, and believed that the app should be pedagogical, that visitors should learn with the app. On the other hand, the representatives of CulturSintra and also the guides that work at Quinta da Regaleira were aware that visitors seek entertainment, excitement, memorable moments. They finally agreed on a concept that tries to conciliate accurate information with entertainment, based on multimedia components and diversified formats: texts and videos are more informative and educational while AR experiences afford more entertainment.

When visiting Quinta da Regaleira, during our fieldwork, we observed that one of the most popular experiences was the AR experience in which a 3D avatar of poet Luís da Camões explains the symbolism of a fountain. This could be considered an anachronism, as Luís de Camões lived long before Quinta da Regaleira was built. Nonetheless, visitors love taking selfies with the poet, one of the most important figures of Portuguese literature and culture.

Luís Patricio also stressed that the participation of visitors is very important, giving as an example the possibility of taking selfies with several historical figures. Thus, “the personal storytelling intertwines with historic narratives”, giving new meaning to the visiting experience. This engagement afforded by the AR experience not only intertwines the physical space with the digital avatars, but also the personal stories with history, adding even more layers of meaning to this complex experiencing of the visit, which can later be shared on digital outlets, reaching new publics and creating more awareness about the cultural heritage site.

But deciding on the content and on the features of the user experience afforded –being strictly informative and educational or including entertainment and interaction– was not the only challenge faced during the development of Regaleira 4.0. According to Luís Patrício, the main barriers were physical and technological. The landscape of Quinta da Regaleira is vast and irregular, most of it covered with rare vegetation that must be preserved, as well as all the constructions, considering that it is a cultural heritage site. Thus, another important challenge was covering the whole property with a Wi-Fi network functioning regularly in a satisfactory manner. The Wi-Fi transmitters needed to be strategically placed, in a way that was functional but also without damaging buildings or vegetation, in an aesthetic manner (hidden). The same challenge also applied to the beacons that signal to smartphones the availability of AR experiences based on geolocation. Furthermore, as the landscape is very irregular, the

signals required a very sharp adjustment, as smartphones could not pick up on a signal referring to an experience available on a balcony above, for instance. This stage of setting up the technical infrastructure at Quinta da Regaleira, testing its interactions with the app and making adjustments took about six months, and the selection and curatory of content took about the same. On the contrary, the technical development of the app prototype took about two months, and was further improved during the on-site testing period.

CulturSintra Foundation is satisfied with the final result and summarizes his view of Regaleira 4.0: "It is an innovative and unique experience in Portugal, that aims to offer a new visiting experience, richer, more entertaining, and above all to enrich the leisure time that each visitor decides to devote to Regaleira".

4.4. Results

The project Regaleira 4.0 presented several technological challenges, all of which were overcome the byAR agency by combining various techniques and technologies: for lack of markers, we used the Instant Tracking technique provided in the Vuforia Framework; to indicate where the "hidden" content was, GPS position and beacons were used; To know where to point the smartphone, a transparent image of the correct place is simply displayed on the screen.

In the development of this project was used Unity3D with the Vuforia framework for Android and iOS in three languages and uses JSON frameworks to facilitate the organization of content and system configurations.

Regaleira 4.0, in spite of recent, has already brought a significant return for Quinta da Regaleira. Luís Patrício highlights the media coverage, which enhanced the awareness about Quinta da Regaleira and created differentiation by associating this cultural heritage site to technological innovation. We also confirmed this during the first stage of our research, the documental analysis, in which we gathered a significant corpus of news about the launch of Regaleira 4.0, all stressing its innovative character in Portugal.

Luís Patrício claimed that it is also noticeable the affluence of visitors that come motivated by an eagerness for trying out the app, attested by the number of downloads at the ticket office, which "already surpasses a few thousands and the demand has been increasing". *In loco*, we observed a particular interest on the part of children, who end up engaging the whole family in the visit and in the AR experiences, and we have also witnessed that those who try Regaleira 4.0 are very pleased. Luís Patrício reported that there has been some interest from other City Councils and companies in knowing more and learning from this experience, thus positioning Quinta da Regaleira as a benchmark, at least nationally, which results also in demand of the expertise of the technology partners involved.

There is a high potential for future benefits. For example, the collection and analysis of data through the app is underdeveloped, as the app currently does not collect any data about its users or usage. Luís Patrício justified that, when the app was being developed, they were aware that a new legal framework would apply to data collection and protection. The new Data Protection General Regulation vigorates in Portugal since May 2018. At the time, they did not want to invest in developing metrics that could, later on, become a problem and need changes. However, we believe that this data could bring valuable insight about the motivations and preferences of Quinta da Regaleira's visitors, help in the identification of profiles and segments, and allow the development of personalized visits, even of responsive and interactive visits.

Luís Patrício sees in the awareness and reputation obtained an opportunity for working on the branding of the corporate brand CulturSintra, which is, so far, fairly unknown to the general public, who is most familiar with Quinta da Regaleira. This would be important because this is an umbrella brand, which manages other cultural heritage sites, and could be a driver for synergies between them and events. The app can evolve into an aggregator touchpoint for all of the cultural heritage sites managed by CulturSintra, all of its initiatives and events.

But what Luís Patrício valued the most are the benefits for visitors, which is the intensification of a visit that he considers fantastic by itself, enhancing its mystery, its fantasy, "giving a completely different dimension to what is Quinta da Regaleira".

5. Discussion

Considering an overview of the research about the application of AR solutions to cultural heritage sites, it is important to discuss to what extent Regaleira 4.0 presents advantages or further challenges.

Damala & Stojanovic (2012) list several benefits that AR may afford the management of cultural heritage sites, namely showcasing vast collections and allowing a more detailed knowledge (and even manipulation) of artefacts. This does not apply to the experience created at Quinta da Regaleira, as the attractions are the buildings, decorations, gardens and nature, and not collections of artefacts.

Through a multidisciplinary dialogue between cultural heritage, management and marketing and new information and communication technologies in the AR sector, we can increase access to information and provide the public with a useful application for a greater understanding, appreciation and conservation of cultural heritage. Mortara et al. (2014) claimed that most AR experiences are informative and educative, but we observed that the most attractive feature of Regaleira 4.0 is its entertainment potential, which appeals greatly to children and youngsters.

In addition, its immersive and interactive character enhances the engagement of visitors. Visitors are allowed to make choices: then can choose five different visits, and also which experiences and information they would like to visualize or not. Also, visitors can use the AR experiences for the co-creation of digital storytelling and personalization, as stated by Stricker et al. (2010).

Regaleira 4.0 is able to address efficiently the problem that it was intended to solve: it makes guided tours to Quinta da Regaleira available on the visitor's mobile phone extension, thus covering the capacity to respond to demand. In addition, it aims to provide more interesting and engaging alternatives to those who were not able to enjoy a guided tour, going beyond maps and guides on paper, signs on the site, and even audio guides. Previously the experience of visitors at Quinta

da Regaleira, without the presence of guides, limited to paper maps or audio guides, caused loss of information and a detailed understanding of the charms of Quinta da Regaleira. It could also cite a distancing between visitors and their families and even the relationship with other tourists. With the Regaleira 4.0 application, the phygital interaction is constant for the understanding of the space and for the physical interaction among the visitors.

However, we believe that Regaleira 4.0 is still a prototype, an early experiment that is not developed to its full potential.

Considering types and formats of AR experiences, Regaleira 4.0 is a mobile guide (Anderson et al., 2010; Ardissono et al., 2012) but it could be further enhanced by including different kinds of games, virtual environments and simulators, making the visit even more immersive and engaging, and enhancing the entertainment afforded.

Furthermore, research highlights the potential of AR technology for personalization (García-Crespo et al., 2009; Kounavis et al., 2012; Mortara et al., 2014; Stricker et al., 2010), which is lacking at Regaleira 4.0. By requiring a login and collecting some information about each user, Regaleira 4.0 would be able to tailor the experiences it affords, and eventually maintain a certain level of engagement after the visit. This is the intention of CulturSintra Foundation for the future, that Regaleira 4.0 evolves into a content aggregator about the Sintra Region, maintaining a regular relationship between the brand and former visitors, motivating them to visit other cultural heritage sites at Sintra, or to revisit Quinta da Regaleira, for instance, in order to attend events.

Another important development would be adding a "social" layer to facilitate the sharing of content, the interaction of visitors on their social media, and also the interaction among visitors (Cortimiglia et al., 2011; Barrile et al., 2019). We have observed, and Luís Patrício reiterated this observation, that visitors love taking selfies with historical figures with Regaleira 4.0 and sharing them on their social media profiles. This is very positive for Quinta da Regaleira, as it expands brand awareness and attracts new visitors. Making the connection between Regaleira 4.0 and social media more intuitive and instantaneous would be important from a user experience point of view, and the shareability of content could be enhanced by adding features that would make it easier for users to build and share their own stories.

Previous research concluded that visitors find AR experiences attractive and that it may favour destination choice (Puyuelo et al., 2013; Chung et al., 2015; Blanco-Pons et al., 2019). However, at this point, the users of Regaleira 4.0 displayed mixed feelings. They all started out excited to try out something new, as most of them never experienced AR before. As they went along, some of them commented about the 3D avatars not being perfect, about proportions and dimensions, about not blending naturally with the physical environment. Jung et al. (2015) claimed that visitors' satisfaction with AR experiences of cultural heritage sites depends on technological quality, quality of content and the personalization of the experience. We observed that some users are disappointed with the technical quality of visual graphics and 3D features, that some skip the texts because they find them long and boring, and personalization is lacking. Thus, Regaleira 4.0 still has a long way to go concerning user satisfaction. As Kounavis et al. (2012) claimed, AR cultural heritage mobile apps are transitioning from experimental pilots to a commercial phase, and the technology still has limitations to overcome, and this is notorious in Regaleira 4.0.

6. Concluding remarks

The success reached by Regaleira 4.0 shows that the benefits of a strategy for dynamizing cultural heritage using AR experiences does not only solve functional problems and intensifies the visit by promoting learning and entertainment, but also created huge added-value in terms of awareness and reputation, being a remarkable tool for cultural marketing. AR is aligned with the perception of online and offline as two intertwined dimensions of our lives, instead of separated. The creation of phygital experiences has the potential to intensify visits to cultural heritage sites by adding layers of information, entertainment and social interaction, and what the visitors value the most is the possibility of adding entertainment to the visits and to personalize them in a responsive way. Yet, there are challenges, mostly regarding technological solutions.

On the one hand, the satisfaction of the visitors is strongly related to the technological quality of the experiences, which has to evolve and improve continuously. In the case of Regaleira 4.0, the technical quality of the 3D graphics needs to be improved. On the other hand, the reliance on the smartphone must be reflected upon, as it is difficult to foster loyalty to users to branded apps, which end up being deleted if not used frequently. Content could play an important role in such gaining loyalty, as other formats such as games and simulations could be included, and, above all, the potential of AR apps for personalization and responsiveness is not being explored by Regaleira 4.0.

We believe that one of the main lessons to learn from this case study is about the potential of AR experiences to enhance brand awareness and reach. Regaleira 4.0 was developed to address a practical problem in the management of this cultural heritage site. However, it afforded unexpected benefits by associating the brand to innovation, improving its awareness and reputation, and by attracting new visitors and new business and partnership opportunities.

In addition, virtual reality and AR can be used to integrate the real world with information from different backgrounds enriched with graphical, textual, and media information, thus adding intertwined layers to the contemporary phygital environment. Real virtual models have become part of the public and also raise awareness about heritage. They cover all the methods to obtain information about brand equity and its communicational dissemination. These phygital experiences are immersive and engaging, contributing to a more memorable experiencing of cultural heritage sites, desirably more satisfactory.

Future research is needed about how to improve the performance of AR, maximize its potential for cultural marketing, and provide information in permanence, as described in this research, with the aim of contributing to the valorization of cultural heritage.

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