Journal of Digital Media & Interaction
Vol. 3, No. 7, (2020), pp. 68-91

# Sensing the territory as an opportunity for the promotion of cultural heritage

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**Abstract**

The promotion of cultural heritage is one of the core challenges in the current technological scenario. Traditional media information is considered not sufficient, slow, not easy to convey the message and does not have working reliability that fulfils tourist demands. The study explores how much IoT-based applications and smart sensors are providing opportunities for the promotion of cultural heritage`s sites. Therefore, this study discusses an ICT-based project, LOCUS that was designed to sense the territory as an opportunity for the promotion of cultural heritage. LOCUS proposes a prototype Bracelet that is based on smart sensors, through prototype bracelet, it is possible to develop a playful scenario in which tourist can interact with cultural sites and objects. Moreover, LOCUS project offers Android-based Augmented Reality application that offers textual and visual cultural knowledge. The final design of the LOCUS prototype application senses territory and promote cultural heritage by engaging people through smart interaction and participation and offer the tourist a playful scenario where they can enhance their wellbeing.

***Keywords:*** *Cultural heritage, Internet of Things, Augmented Reality, participation, promotion.*

## 1. Introduction

The appropriate uses of Information and Communication Technologies (ICT) can change the dynamics of urban and rural territories, that helps to promote cultural heritage sites (Roberts, Anne, Skerratt, & Farrington, 2017). Therefore, ICT has a massive contribution to the promotion of cultural heritage content through embedded cultural objects, locations, and Augmented Reality (AR). Thus, ICT makes it possible to change the old way of analyzing cultural heritage content (Alivizatou-barakou et al., 2017).

Presently, the Internet of Things (IoT) is one of the novels and emerging concepts that made many changes in numerous fields in terms of smart intelligent and technological aspect. IoT is a concept that represents a mixture of different networks, in which physical objects are connected through electronic devices and software applications, which allows the physical devices to gather data from various destinations, such as browsing the websites, sending an email, and multimedia contents. Meanwhile, many developed countries, like, the United States of America, Japan, and European countries are considering IoT as the idea of novelty and development, both at an academic and commercial level. However, numerous universities', industries and private research centers are doing extensive research on IoT technologies and their characteristics (Ben-daya, Hassini, & Bahroun, 2019). The IoT-based applications have very broad characteristics which have the capability of changing the perception of people about any objects. Likewise, Augmented Reality (AR) is a currently emerging technology that made numerous changes in the perception,

ISSN: 2184-3120

observations and way of thinking of tourists about heritages sites (Rauschnabel, Felix, & Hinsch, 2019). The primary function of AR technology embeds the virtual objects on the real world that allows the users to have virtual and real-world experience at the same time. Although, AR technology does not change the real world, add unique virtual objects that help to enhance the observation of visitors without changing their perception about the real world. Mobile AR trends are new in the technological dimension. From the mid-1990s, the AR got a very prominent position in the technological market and developed many sectors such as education, entertainment, tourism, and marketing and particularly in geographical discoveries (Flavián, Ibáñez-sánchez, & Orús, 2019).

Cultural heritage is considered a treasure and the identity of a nation and a vital source that is transmitted from one generation to another. Indeed, cultural heritage is the hub of ancient's knowledge and history that is hidden under the magnificent architecture of buildings, location, and objects. In general, tourists are seeking to learn the history of cultural heritage that is hidden under the mist of time. The learning from heritage sites is informal education; few people have access to get this kind of education from academic institutes. Consequently, learning AR`s method initiates a process in which cultural heritage depends on intrinsic motivation that helps to promote cultural heritage and make it enjoyable and playful for visitors (Camilo, Fabregat, & Carrillo-ramos, 2020). To enhance knowledge about cultural heritage sites, then cultural heritage sites must be equipped with digital assistance that could be accessed online and onsite. This study explores existing IoT-based applications that are facilitating the tourist to explore the cultural heritage sites and providing online services to the visitors, that are helping to enhance visitor's knowledge, participation, and cultural promotion.

Furthermore, IoT applications can provide interaction scenarios in which cultural objects, fields, gastronomy contents and historical building transforms into reality through AR. After exploring the existing knowledge, this study will offer a model of a smart environment for Amiais village, which is a rural site, located in the Centre Region of Portugal that will be based on a smart bracelet and android apps. The model design of LOCUS study will be capable of engaging the tourists to participate in local activities, and the model will enhance their knowledge through embedded technology. This study offers a playful scenario.

## 2. Background

Preservation of cultural heritage and its landscapes` assets are essential for promotion and representation of local cultural identity. Cultural components, properties and landscape is a wealth of ancient human civilization due to its value and uniqueness (Holm, Burnside, & Mitchell, 1987). The cultural heritage and its components are not vital components of human life that helps local development; however, cultural heritage is the evidence of living human memory (Kalman, 2017). The cultural heritage is the primary source of motivation and inspiration that provides a comprehensive reference to human heritage. Although, the cultural heritage proposed significant

resources which not only describe the magnificent monuments and ancient environment but also recall the ancient time memory(Lowenthal, 2018). Improvements in new emerging technological tools, especially in virtual reality, AR and smart sensors are making it possible to sense the cultural heritage territory. Moreover, these technologies promote cultural heritage, as well as cultural properties and increase the curiosity of the visitors about the cultural product. The AR allows the visitor to immerse in the virtual world and interact as he/she interacts with the real world, being this AR world generated by computer programming. Thus, currently, AR is one of the essential concepts in the medical, education and tourism because the design of this concept can run multiple application domains. Consequently, AR technology is becoming an accessible technology both inside and outside scientific society.

AR introduced as a concept in the digital world, in which information overlay on user's real world, the users can get this information by using smartphones, smart glasses and mounted head technology (Rauschnabel, Brem, & Ivens, 2015). Hence, the tourism sector started to understand the uses of overlaying digital information technology that is embedded in the real tourist environment (Jung, Chung, & Leue, 2015). There are two main functions of AR, such as navigation and overlay information features that make AR technology more attractive and appropriate for the tourism sector, especially in cultural heritage context(Tscheu & Buhalis, 2016). Likewise, AR provides a platform in which cultural heritage objects and buildings have permission to bring back the ancient environment and events in the present era. Moreover, AR explains hidden stories under ancient architecture (Berube, 2018). Presently, AR is the most appropriate technology from the tourist point of view because it provides the opportunity to experience cultural heritage through a very novel way and to enhance tourist knowledge via virtual reality. Likewise, AR technology is also equipped with GPS (Global positioning systems) technology, which allows tourists to retrieve context-based information. Also, image recognition technology makes it possible to scan places, buildings, objects and dig out information about cultural heritage sites(Hoshang Kolivand, Abdennour El Rhalibi, Mostafa Tajdini & Abstract, 2018). ICT-based applications and novel technological developments had made cultural heritage (tourist) experience more social, reliable and efficient (Tom Dieck & Jung, 2015). The existing research on AR has indicated that its components can promote the cultural heritage and create an interactive, and pleasurable environment for tourist that is helping to enhance the tourism experience (Moorhouse, Dieck, & Jung, 2017). AR application has unique features that motivate the user to learn and participate in an environment through interactive components(Chen et al., 2019). Furthermore, in augmented reality, the objects and locations are embedded with some vital information such as history, and stories that increase the visitors' curiosity to learn about objects and cultural heritage sites(Moorhouse et al., 2019). Relatively, a study presented by Dieck and Jung, (2015) named A theoretical model of mobile augmented reality acceptance in urban heritage tourism. This study is about cultural difference in augmented reality in archaeology sites shows that most of the Western tourist wanted to see heritages sites through AR application. Therefore, museums are transforming their environment to make museums environment more immersive, enjoyable and museums are being converted into an educational platform. Existing studies are indicated that ICT-based

applications have the potential to promote cultural heritage through augmented reality. Following studies have been analyzed studies.

## 2.1. Study 1 Interacting with a social web of smart objects for enhancing the tourist experience

This study was conducted by Cena, Biamino, Chiabrando, & Fassio (2012). The main objective of this study was to develop an IoT-based social intelligence environment. Due to intelligent social capability, the objects tell stories, histories of objects and communicate with visitors for knowledge sharing. This study has a design that is based on a recipe of different ingredients. A first ingredient is a smart object that can manage and covey embedded information to visitors. The flow of information enhances communication level between object and visitors that builds a virtual social relation among the visitors and objects. The second ingredient is a social networking and web servicing. Likewise, social networking platform behaves as traditional social networking sites behave. The third ingredient was to develop a natural interaction between objects and visitors, which is enhancing the wellbeing and joyful experience. The last ingredient is people`s experience during interaction with an object on different devices and a web-based platform called the continuum of experiences. The goal of all these ingredients is to develop a smart environment where people and objects can communicate with each other.


**Figure 1. Example of the wheel on the iPhone. Source: (Cena, Biamino, Chiabrando, & Fassio 2012)**

The presented study settled an application that has two main parts: the first one is “get in touch”. In this part, the visitors can take pictures, share geolocation, bookmark, and search objects. The second part provides interaction between users and objects; through this technique, users also interact with their friends by sharing pictures, messages and location that develop an extensive social network. The third ingredient is to develop a natural interaction between objects

and visitors, which is enhancing the wellbeing and joyful experience. The last ingredient is people experiences' during interaction with an object on different devices and a web-based platform called the continuum of experiences. The goal of all these ingredients is to develop a smart platform where people and objects can communicate with each other.

Similarly, behind the scenes, the architecture of the application has two phases. The first phase is a server-side, which serve to manage all activities. The second phase is the user-side that creates and manage interaction environment among the devices, objects, and people. This application is designed for the iPhone and ran on 3G telecommunication.

## 2.2. Study 2 PLUGGY: A Pluggable Social Platform for Cultural Heritage Awareness and Participation

The second study`s (Frangakis et al., 2018) primary goal is to provide a platform, where the user is not only consuming, observing but also generating knowledge and sharing it with tourists. This study introduces a very novel concept called PLUGGY; the design of PLUGGY allows the citizens to share their knowledge and experiences. PLUGGY consisted of three main components and four subcomponents, such as (I) the social platform that is situated in the centre of PLUGGY. This platform ensures that people should be in the centre of this concept where they can use many services from the application, for instance, sharing their virtual exhibitions, virtually visiting museums, access the digital libraries, and upload multimedia contents for social interaction. (II) The curatorial tool allows users to use interfaces and PLUGGY content. However, (III) PLUGGY applications provide two sides, one side provides them to visit the museums, and the other side uses the curation tool and experience sensory system. Additionally, PLUGGY have four subdomains in which users experience (i) AR application, (ii) 3D Audio application, (iii) collaborative Game application and (iv) geolocation. This study used a user-centred approach with several case studies evaluated for the final prototype design that can engage the visitors in social relation via AR. The application of this study takes people into a world where they will experience the virtual and real world.

## 2.3. Study 3 Blending customization, context awareness and adaptivity for personalized tangible interaction in cultural heritage

This study conducted by Not & Petrelli (2018). The authors introduced an inclusive method to develop a smart interaction scenario which can deliver cultural heritage content by online and onsite. The main objective of this scenario was to provide a smart interaction environment in which visitors could personalize the information and experience for tangible, embedded and embodied interaction with smart objects.

**Figure 2. Voices from the Past in Fort Pozzacchio is a permanent installation at the Museo Storico Italiano Della Guerra. At the entrance, the visitor receives a pebble used to activate content at different stations along with the visit, when leaving the visitor returns. Source: (Not & Petrelli 2018)**

Similarly, in the smart scenario, every object has embedded with story or history that facilitates the visitors while they visit the online or onsite scenario. In this scenario, the visitors can personalize the tangible interaction in cultural heritage by adaptivity and context awareness. The adaptivity allows the visitors to customize the application settings according to their will.

The primary responsibility of context-awareness function is to sense and respond according to the situation. The prototype application had been installed in different locations such as WWI trenches (install Bluetooth base loudspeaker) the Hague and Atlantic temporary wall (interactive, personalized postcard) Hunt museum (Loupe is mobile-based augmented reality application) and Museo Della (the interactive plinth) for the case study.


**Figure 3. The Loupe was used at the Hunt Museum to get information for objects belonging to different thematic trails by matching different visual markers, e.g. a shamrock for a historical trail or the shape of a building for a trail on architecture. Source: (Not & Petrelli, 2018)**

Similarly, this conducted two more complementary studies; the first one is based on a meta-analysis of the literature review to understand the features of the personalization system. The literature briefly discussed the comprehensive features of the environment personalization. There is a list of the essential features that could enhance the personalization experience for cultural heritage: (I) stable visitor profile, (ii) visitor model related to the current visit, (iii) interaction or social context, (iv) model of the environment and (v) features of the content. Although the literature highlighted the essential features for the implementation of the system, still many essential features are missing. The second complementary study is based on a user-centred and qualitative study. There were 25 participants from the school of thoughts such as computer engineers, designers, experts who have experience in cultural heritage, especially in personalization. They have participated in the enhancement and development of personalization features. After getting the final suggestion from the participants, a codesigned phase was conducted with curators and

museum experts for finalization of the personalization features. The personalization for tangible embedded and embodied for cultural heritage has potential in which visitors can customize their profile, application features and interact with smart object for participation, and social interaction with cultural heritage.

## 2.4. Study 4 Augmented Experience in a cultural space through social participation

This study was conducted by Díaz, Bellucci, Yuan, & Aedo (2018). This study uses the Internet of Things (IoT) as the primary tool, moreover social computing and Augmented Reality technologies included to interact with visitors for participation at cultural heritage sites. In this regard, the primary objective of this study is to provide a Social Display Environment (SDE) to visitors at cultural heritage spaces such as museums or cultural heritage sites. Social display environment (SDE) enriches the tourist experience by relying upon two essential sources of motivation social interaction and physicality Social display environment (SDE) equipped with RFID, Cameras, and smart sensors that can place different tourist places and display the objects. The tourist can interact with the presented narratives whilst still watching the objects (Diaz, Bellucci, & Aedo, 2015). Presently, the museums are facing challenges to attract more visitors towards the cultural heritage spaces. Thus, the design of this study helps to overcome these challenges by using IoT, social computing and AR. In fact, in ICT-based applications, visitors have more freedom to interact with objects. SDE (Social Display Environment) turn the physical objects into social objects that raise argue and discussion among the visitor who is physically present at cultural heritage sites. The interaction with the object is only possible with the help of augmented reality. The implication of any topic is possible through RFID (Radio-frequency identification) tagging scheme. Likewise, through this technique, it is workable for users to produce digital content, and information that can be overlay between users and physical objects; this digital information will be visible on the display screen. Social Display Environment (SDE) provides opportunities for visitors to share their experiences by commenting on the object, telling their stories, uploading their videos and rating the object interaction experiences, all these activities will be visible and tagged with objects for other visitors.

**Figure 4. How to interact with a video entry with the user interface: A visitor can watch a video and rate it (on the left); watch other visitors' comments (in the middle), and generate a comment in the form of a video and/or text message (on the right). Source: (Díaz, Bellucci, Yuan, & Aedo, 2018)**

Furthermore, this study proposed three main scenarios. The first scenario is co-construct and share. The main objective of this scenario is to develop AR platforms for visitors to express their sentiments, moods, expressions and communicate through mobile phones and share them on social media platforms. The second scenario is interacting and sharing content with visitors. In this scenario, people experienced the augmented-based hologram bubble, that always follows them, and provides them with visual content such as text or image about the items that are displaying in the museum. Likewise, through this bubble, it is possible to interact with other people for promoting the discussion over an object or topic. In the third scenario, tourists can generate and share information about a specific piece of the exhibition via AR.

Although all these scenarios are different from each other, two factors are common in all scenarios: visitors and objects. The visitors can physically interact with each other and their participation for cultural heritage promotion. The second common factor is social interaction, in which visitors can express their feelings, share their interaction experiences with friends, family members and the world about the real object. Social Display Environment (SDE) interface is designed for two platforms: one is a 47 inches LED display showcase that is built from MyMutouch; the second is smart mobile devices. The SDE platforms contained five steps or layers such as Mondo database, SDE showcase (web user interface), and SDE mobile app (web user interface), RFID (Radio-frequency identification) reader (Arduino), microcontroller and RFID tagged objects.

MongoDB is a database service that stores the digital content of the RFID (Radio-frequency identification) tag. Every single entry related to objects such as comments, videos, images, time, date, properties is recognized by unique tags. Thus, when someone wants some specific information about objects, the associated RFID tags to get active, Arduino microcontroller read the tag information and communicate through the digital message with a web server. The web server searches this information via tag ID and recovers the information from the database. After retrieving the information, the server sends back to the user interface and display that information on him/her devices.

### 2.5. Study 5 Tourists responses to mobile augmented reality travel guides. The role of emotions in adoptions behavior

This study was conducted by Kourouthanassis, Boletsis, Bardaki, & Chasanidou (2015). This study explores the usage of mobile phone technology in daily life activities. The mobile phone technology is equipped with different applications such as maps and AR. Consequently, with the help of mobile phone applications, it is possible to travel to the remote area of the world without any physical guidebooks or maps. To consider this, the study presents a CorfuAR concept.

CorfuAR is a fully workable prototype mobile AR application. The CorfuAR has two main features: personalized content for users and facilitates the tourist through a navigation application. The presented application is designed for Android devices and has two versions, the first one personalized and the second non-personalized. The application takes care of tourists' points of interested, moreover, gives them a platform where they can interact through social communication with their friends, and family.


**Figure 5. CorfuAR travel guide in action. Source: (Kourouthanassis, Boletsis, Bardaki, & Chasanidou 2015)**

Moreover, this study has another objective that is to evaluate individual adoption behavior towards the CorfuAR. The study used a random approach method, in which the researcher personally approached a group of tourists, explained the study motives. The researchers used a questionnaire method as a study instrument that is based on a unified theory of acceptance and use of technology, which is associated with UTAUT2 framework. The questionnaire contained four-dimension factors (colourful attributes, continue intention, emotional states and cognitive traits) and eight measurement factors (performance expectancy, effort expectancy, behaviour intention, pleasure, dominance arousal, personal, price value and innovativeness). The final study results indicated that a total number of participants (tourists) of 105, in which 69 are those tourists who used the personalized version and 36 tourists that used the non-personalized app version.

## 2.6. The reasons for choosing these studies

All selected studies are based on a unique and comprehensive design that offers usage of novel digital tools to the promotion of cultural heritage sites. All selected studies have the main objective to promote interaction experience among the tourists. therefore, design characteristics of all selected studies engage the tourist directly or indirectly, the interaction amongst the tourist

enhances the curiosity of tourist to visit and explore the sites through digital platforms. Due to these features, we selected this studies to discuss in this paper.

## 2.7. SWOT analysis of presented case studies

### Table 1. Case studies' SWOT Analysis

| Study numbers | Strength | Weakness | Opportunity | Threats |
|---|---|---|---|---|
| 01 | This study has two very essential components that increase the worth of study in scientific society and tourism sector such as one is smart objects interact with visitors and second is social networking. | This Study`s application is designed for iPhone devices that reduces its value because until Feb 2020 73.3% user use android application and only 25.89 % (stat counter, 2019).<br><br>Other weakest part is a design platform and this study neglected 73.3 percentage of android users. | AR and smart objects-based applications are growing very rapidly in tourism sectors. therefore, this study has a huge opportunity to get a prominent position in the tourism sector but need to provide this application on other platforms such as window and android application. | This study is designed for iPhone platforms that is a question mark for its growth and future in the mobile application market because android devices have users as compared to iPhone devices. |
| 02 | The study has a very essential component that's is user participation in knowledge-generating and sharing this knowledge with others. Secondly this study support AR and VR tools. | This study did mention that app is designed for android, window mobile or iPhone devices.<br><br>There are many social media platforms available where share their knowledge not only cultural heritage but about various fields.<br><br>This structure and the operational method it is not replied able due to complex designed of platforms.<br><br>This application does not provide a camera option in which people can interaction through video or voice calling to share their experience | VR and AR trends are growing very rapidly and are these trends that will encourage people to experience this application | Digital market trends have been changing very quickly where people more interactive option such as Audio, video, SMS, social networking, AR and VR experience for knowledge sharing but this study does not provide audio and video interaction. On the other hand, their many applications where people share their knowledge through video and audio conversation such as Facebook |
| 03 | Strength of this study is to provide cultural heritage knowledge via online and also on site<br><br>Secondly, this study provides a smart interaction environment in which visitors could personalize the information and experience for tangible, embedded and embodied interaction with smart objects.<br><br>Moreover, this study provides group-based games that enhance the reliability of this study among tourists. | The weakest part of this study that is, the system takes all decisions what to presents to which visitors and when and how. | Concept of this study has the potential to grab the attention of a huge amount of people because this study not only provides indoor activities but also outdoor activities. | Poor networking services could discourage visitors.<br><br>Lacking training opportunities for elderly people who have not have digital skills will reduce the amount the elderly population not to use this platform. |

| | | | | |
|---|---|---|---|---|
| 04 | The strength of this study is to provide social display environments (SDE) that encourage the people to show their participation in cultural spaces whilst keeping the physical connection with the exhibition objects.<br><br>SDE, users can generate digital information and makes augmented reality content to augmented physical artefacts in an exhibition. | This study only relying on RFID tagging scheme. In this scheme user need to scan the tag then they will able to experience these platforms. | In the tourist sector, this study can increase the numbers of tourism because in this tourist can take their stories and AR material that is accessible for other visitors | RFID is an old technique and without proper information or guidelines, it will be hard for users to find out the tags and scan it. For this study, GPS+AR is the biggest threat |
| 05 | This positive side of this study to personalize content for users and facilitates the tourist through a navigation application. The presented application is designed for Android devices and has two versions, the first one personalized and the second non-personalized. The application takes care of tourists' points of interested, moreover, gives them a platform where they can interact through social communication with their friends, and family. | Study neglected the iPhone users<br><br>The study does not offer offline use of app because when people will go remote areas where will be no internet services then how people use this technology. | This application has a market among backpackers and free traveller. | There are already many apps in the market that giving the same facility such as google maps |

## 3. LOCUS Project sensing territory for cultural promotions

The primary objective to discuss all these studies was to understand the vital role of technology that is helping to disseminate and promote cultural heritage knowledge among the tourists. Secondly, the stated studies have used similar approaches as compared to LOCUS project going to apply such as, these studies have developed and evaluated an IoT-based prototype system that can explore the cultural contents and enhancing the cultural heritage of rural territories. Moreover, IoT-based applications have the original features to make cultural heritage sites sense-able, enhance the tourist interaction with cultural objects and boots the tourist industry through a novel way. Likely, the LOCUS project is a multidisciplinary project with the primary goal of design, develop and evaluate IoT-based systems. Secondly, there is an object of understanding the potential of a prototype that is helped to support playful intergenerational engagement for producing and discovering the cultural properties and enhance the knowledge about cultural heritage sites. The LOCUS project is using a playful and immersive cultural heritage tourism approach that is helpful for socioeconomic and cultural development. In this context, the LOCUS project offers an immersive gamified experience for tourists; through this experience, tourist will learn about the cultural object and historical sites. LOCUS project is being developed in the Centre Region of Portugal, at Amiais' village. Amiais is a rural village, which has 15 inhabitants with ages between 3 and 90 years old, but only three of them are children. The main population of Amiais is aged. LOCUS project is divided into 11 tasks (each of one with subtasks). Apart from the task's characteristic from these type of projects (team management, internal and external communication, bibliographic research, etc.), other tasks gain relevance. The first one was the ethnographic research, which allowed the team to know the territory, the population and Amiais' cultural heritage. This task was also important for the definition and construction of the IoT-based prototype, by knowing the most important aspects of cultural heritage it was possible to feed the prototype with real data. Finally, it is intended to develop a fully functional IoT system and test it in a large-scale reality, which will also be at Amiais.

### 3.1. IoT-based prototype

The LOCUS project offers a prototype IoT-based smart bracelet that is capable of sensing territory through smart sensors. The Smart sensors are capable to promote cultural activities and knowledge due to its storage capacity for a long period by using energy consumption (DOE-USA, 2015). Secondly, the prototype communicates through android application. The design of an Android app is to make possible the connection with the smart bracelet through Bluetooth and internet technology for visual communication. Furthermore, the combination of Android application and smart bracelet to make it possible to interact with everyday things and explore the cultural heritage sites through AR. Lastly, through prototype, the user will be capable of producing and sharing multimedia contents with their friends, family members and within a community.

**Figure 6. LOCUS Project`s IoT-based smart bracelet sketch. Source: LOCUS project.**

### 3.1.1. Instruments, techniques, and participants

Design of this study is for the Portuguese population. this selected population small and remote village named Amiais. Amiais village literacy rate is not very high, most population cannot read and write properly. Therefore, there is no chance to provide written material and get feedback in written form from the Amias villagers for data collection. for data collection, this study conducted the oral interview. Firstly, we took the pre-design interview, to know the perception of villagers about technology and their digital expertise. Based on the pre-design interview, this study designs develop a prototype. after the initial development of a prototype, the prototype presented to the Amias villagers for their oral feedback. Later, one basis of feedback that ios got from Villagers of Amiais, developed the final design of the prototype.

### 3.1.2. Location: Amiais village

This study is going to be conducted in a Portuguese village named Amiais. Amiais village has been selected due to its location, essential cultural festivals, and traditional agricultural activities. Amiais is a Portuguese village that is situated in Couto de Esteves Parish, in Sever do Vouga municipality, Portugal. The village is culturally enriched, and it is surrounded by green vegetation, magnificent landscapes, and mountains scenery. There are many religious festivals in Couto de Esteves parish: Santissimo Sacramento; São Francisco de Assis e Nossa Senhora do Amparo.


**Figure 7. Corn threshing real image. Source: https://www.gettyimages.co.uk/detail/news-photo/great-barrington-barn-greatbarrington-gloucestershire-1895-news-photo/464409841?adppopup=true.**

Furthermore, there is a folk Portuguese traditional place called *Eira comunitária.* In this context, *Eira comunitária* was a place where, traditionally, the people from the village gather for threshing corn, by adopting an ancient method. For threshing, there is a wooden made stick that is consisting of two sticks, one is long and second is short that is connected at one end by a short chain or rope. Likewise, the men and woman hold the long part of the stick and hit the small part that connected with a chain on the corn for corn threshing.

## 3.2. How does the prototype operate?

The smart immersive cultural heritage tourism approach will be applied in Amiais village. Through this approach, tourists will have a smart environment experience to participate in cultural activities and enhance their knowledge about Portuguese rural life. The smart bracelet will embed smart sensors and AR. When tourist's check-in at Amiais village they will get an automatic notification from the app. The notification will tell the tourist their exact location. Furthermore, the notification will explain how to use the bracelet and the app. After reading the notification, tourists will get in the app and will choose different locations and types of cultural activities. Once they select the desired activity, the google maps will guide them to find the location, for instance, when tourists select "*Eira comunitária*" activities right after selection, the google app will indicate the exact location where that happens. Once the tourist arrives at that location, he/she needs to find the RFID (Radio-frequency identification) tag and scan it.


**Figure 8. Corn threshing. Source: https://www.agefotostock.com/age/en/Stock-Images/traditional-threshedgrain.html.**

After the scanning, tourists will be able to participate in the "*Eira comunitária*" activities and pretend like villagers, as villagers usually do by using a specific stick for corn threshing. The tourists will pretend to have a stick in their hands, and they are threshing the corn in real life. The tourists will get points on their speed of threshing and numbers of corn threshing. The points will develop a playful scenario among the tourists and increase their willingness to participate in more activities and learn more about the place.

Furthermore, Radio-frequency identification (RFID)tags will be placed in different parts of Amiais village. The RFID tagging scheme will provide the tourist with the opportunity to explore more about Amiais village and its culture. For example, the tourist scans the tag that is placed on "*Desfolhada*" (a traditional activity).

**Figure 9. *Espigueiro* or *Canastro* (Amiais) (Corn storage place). Source: LOCUS project.**

The information in the tag will be of two types: text information in which they can read about objects and cultural heritage and, secondly, they will have virtual reality experience in which they see virtual people working in a traditional "*Desfolhada*". Lastly, the tourist will have the opportunity to share their experience with their friends, family, and community by producing multimedia content such as videos, pictures, or sounds.

### 3.3. LOCUS project development stages

To develop the LOCUS smart bracelet and AR experience, this study adopted the five following stages.

#### i) Ethnographic Research

The first stage is ethnographic research, in which the researchers will live within Amiais village community. By living with Amiais` population that will help the researchers to discover folks' stories and ancient ritual activities that are hidden under the mist of time. Secondly, the researchers will explore the habits and perception of villagers about technology. These practices will help to design playful and interactive services.

#### ii) Reflection and Creativity

This stage will encompass assessments, discussion, interpretation, and ties all gather knowledge that was obtained from the ethnographic stage. Furthermore, LOCUS will conduct some brainstorming session with tourist, stakeholders, and inhabitants. These sessions will help to imagine a scenario that will be based stone for IoT playful and intergenerational experience**.**


**Fig. 10. LOCUS development stages. Source: LOCUS project.**

After conduction creative session, the researcher will sketch testbed infrastructure, define its technical, hardware and software specification that will help to develop a smart bracelet, AR scenarios and mobile application.

#### iii) Participatory design and Agile development

After drafting IoT testbed, mobile application prototypes, the researcher will deploy a prototype in Amiais. First test experiment of the prototype, the researcher will invite the local inhabitants, tourist, and stakeholders to participate and test prototype. The reason behind this invitation is to initiate designed and agile development methodologies.

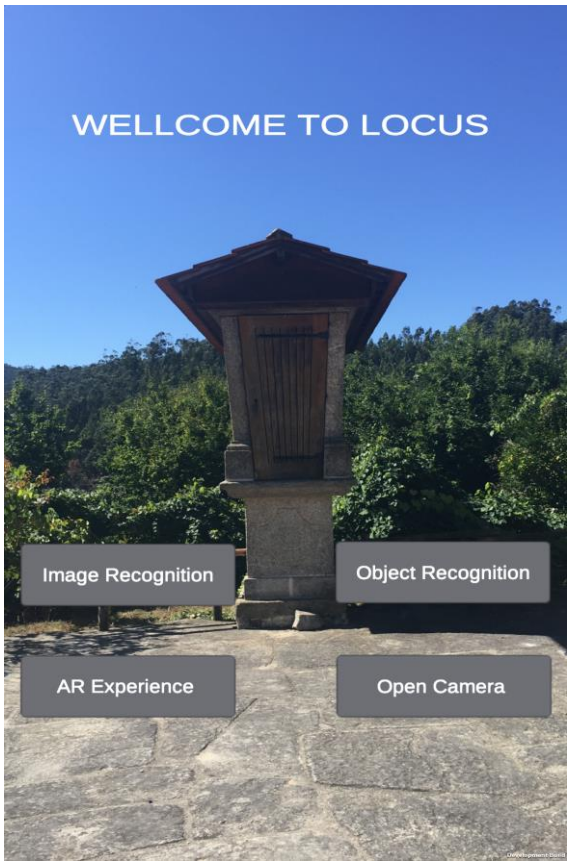


**Figure 11. LOCUS' Android App screenshot. Source: LOCUS project.**

The users of the prototype will have a session for their training on how to use this prototype and adapt the overlay representation of traditional design and development tools and process, to ensure a high degree and quality of participation. Sprints of designs, development and testing will bring to life a consecutive version of the IoT systems until a final prototype version is achieved.

### iv) User testing

This stage carried out a large scale IoT prototype system testing and evaluation through the participation of different user groups such as children, young people, elderly, tourists and intergenerational, etc. At the end of this stage, results will help to the design final interaction functions of IoT systems. At this stage, the collected data will provide a) an understanding of individual characteristics like digital literacy, age, educational background, culture, goals and way of living etc., may impact the way people interact in/with a playful social IoT system and how they cooperate in creating and exploring cultural contents; and, b) how the physical and technological characteristics of smart objects impact playful and intergenerational interactions and collaborative exploration and creation of cultural content.

### v) Sustainability and Mergeability models

Based on the results of all the previous stages, LOCUS final stage aims to ensure the sustainability of the IoT system beyond the lifetime of the project. The involvement and

commitment of the stakeholders will be fundamental to guarantee the sustainability of the IoT system; thus, the strategies to do so – which may include, for example, commercially exploiting the system, integrating it into advertised national tourist offers, etc. – should be jointly designed and negotiated. This last stage also comprises the development of a model for the promotion of rural territories in a playful and immersive cultural heritage tourism approach that will make possible the migration of the used methodology and the developed IoT system, to other rural territories that share cultural heritage aspects with Amiais village.

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## 4. Cultural heritage sites and IoT solutions

Preservation of cultural heritage sites, as well as the value of relics covered within the heritage site, is an expansive job. to prevent serious damages and need for the promotion of heritage sites and interaction between tourist and sites, this study proposes a low-cost prototype, simple, efficient and no invasive IoT based solution for the preservation of the history of the cultural heritage site. The study proposes a technological solution that is consist of three-level as shown in the fig

### i) Perception Level

The perception level of the prototype- is created of small, low-cost, and powerful tools that are adept to sense process and communicate effectively. For interaction between objects and tourist that may influence the heritage and tourist relation, different types of smart sensors deployed inadequate barriers, can be used motion detector, and accelerometer can be placed on smart bracelet and heritage sites. Accelerometer and motion sensors will interact with objects with the help of the HC-12 communication module for example when a tourist move his or her bracelet from X-axis to Y-axis they LED light will turn off that is embed with cultural objects. Secondly, when tourist moves the bracelet from Y-axis to X-axis then windmill turn on. Moreover, bracelets also embed with RFID technology, when tourist scan the bar code that is displayed on the object will listen to the traditional music of Portugal or stories about an object. All these smart sensors attached to the programmable small computer board Arduino UNO that study proposes as a key building component of solution due to its small size powerfulness, low cost, and customizability. The Arduino UNO designed to offer various input and put peripherals and communication network, which makes it an adequate part of the proposed IoT based prototype application solution. The Arduino equipped with smart sensors become a smart and intelligent device and has a unique IP address, which makes it rare and recognizable in the network of interconnected devices. After collecting targeted data, sensors are becoming transmitted to the networking level.

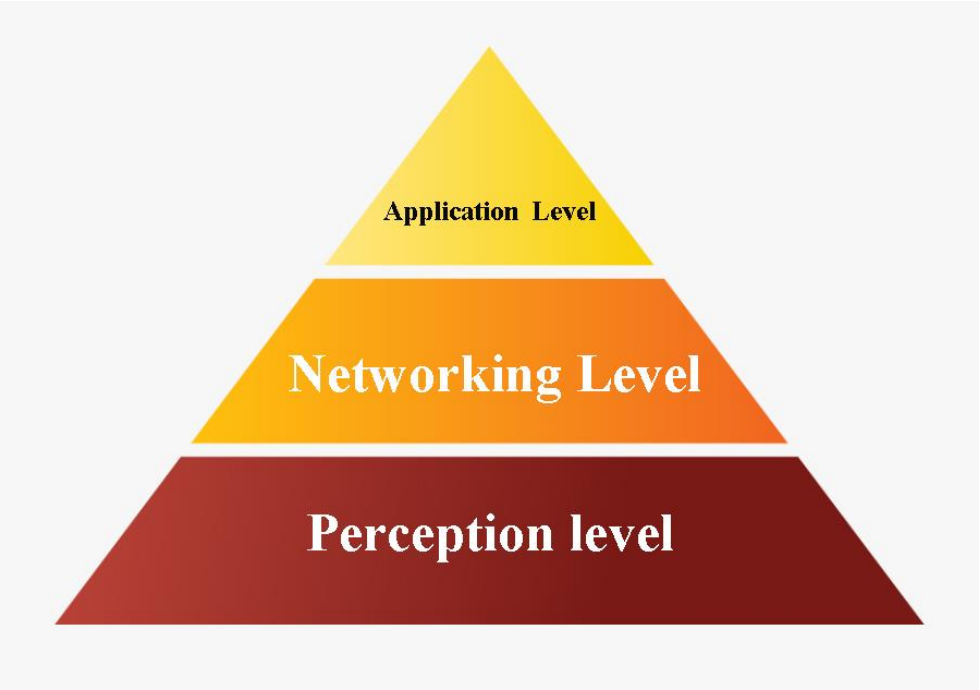


**Figure12. Three-level of IoT application design**

### ii) Networking level

Transmission and network-level have responsibility for broadcasting data from the perception level to the upper level and devices data from the upper level. the Arduino UNO can play a role of the gateway of application. Placed at the edge of the monitoring network, it cooperates with the smart sensors on one edge, and with the backbone network on the other edge. It is also contained a Fog computing level that can screen out the information, performance simple processing and pass on only the resulting data and information to the cloud. in this context, the old problem associated with Cloud computing solutions, for example, latency issues, Bandwidths are effectively resolved. To reduce energy consumption, the deployment of energy-efficient communication technologies is an appropriate technology for this project. For instance, in the proposed methodology the smart application can communicate with each other using Arduino, Bluetooth, HC-12(Wireless communication module) or WiFi, while smart application and Gateway, that can act like a Fog server, can communicate via WiFi technology.

### iii) Application-level

The application-level offers data processing, analysis, and storage, and intelligent, high quality and customized application to the end-user. The data or information collected from various sensors can be stored in both the remote and local storage database. If there is no Fog computing level, a wide range of information and data is being stored at the Cloud stage. The next phase is information and data sorting and extracting useful information. Focal point is to realize the application that will enable the real-time information gathering and sharing, remotely and locally

supervising measured data as well as a remote control, based on visualization and analysis. With the help of knowledge centered and machine learning practices, the protagonists can be brought leading to the various time and intelligent decision that contributes to the prevention of any damages to immovable or moveable cultural heritage. The LOCUS proposes a smart solution, based on precise information and the right knowledge, automatically makes applicable decisions. The advantage of LOCUS application is in fact that there is no need for cellular net data, cable net and cabling that is expensive and invasive that would not be suitable in this prototype. The offered methodology enables 24/7 service accessibility, generate accurate and specific information. LOCUS`s unique solution is flexible and can be designed to the specific use- case scenario by adding the extra elements and services. The Fragile aspect of this solution is the lifetime as the sensor's nodes are battery-driven devices. Prolonging the lifespan of smart sensors node and entire IoT based application can be realized by consumption decrease. This can be accomplished with the help of sufficient sleep-scheduling algorithms and implementing harvesting tactics, like the usage of solar panels.

## 5. Limitations of the prototype

However, some limitation noticed in the prototype such as village Amias is in very remote areas. therefore, there is a very weak or some part of the village there is no cellular internet service available. in this context, prototype operational service and access is limited, and people only use in specific locations of Amiais village, where Locus team will install Locus`s Platforms.

Secondly, this project is based on the latest technology and Locus Team made a prototype that is very simple and easy for its operation that everybody can use it easily but in Amiais village most of the people don't have basic education to read and write. therefore, Locus`s team will also conduct the workshops to train people on how to operate the Locus prototype.

## 6. Conclusion

In the current digital scenario, it is essential to use smart technologies for exploring cultural heritage sites like smart sensors. ICT technologies have the potential to promote cultural heritage and knowledge. ICT technology uses smart sensors that are autonomous and energy-efficient. Therefore, ICT-based smart technologies are an alternative to traditional media. Indeed, traditional media such as print media (newspaper and magazine) and electronic media (TV and radio) have limited boundaries to promote cultural heritage, especially while people are visiting the cultural heritage sites. Unlikely, ICT-based applications are opposite to traditional media mostly because they are always available to serve the users anytime, anywhere and with no operational restriction. Likewise, study 1(Cena et al., 2012) was to develop an IoT-based social intelligence environment due to intelligent social capability, the objects tell stories, histories of objects and communicate with visitors for knowledge sharing. Similarly, the second study`s (Frangakis et al., 2018) primary

goal is to provide a platform, where the user is not only consuming, observing but also generating knowledge and sharing it with tourists. This study introduces a very novel concept called PLUGGY; the design of PLUGGY allows the citizens to share their knowledge and experiences. Furthermore, study 3 (Not & Petrelli, 2018) provides a smart interaction environment in which visitors could personalize the information and experience for tangible, embedded and embodied interaction with smart objects. And, study 4 (Díaz et al., 2018)the study uses the Internet of Things (IoT) as the primary tool, moreover social computing and Augmented Reality technologies included to interact with visitors for participation at cultural heritage sites. In this regard, the primary objective of this study is to provide a Social Display Environment (SDE) to visitors at cultural heritage spaces such as museums or cultural heritage sites. Lastly, study 5 (Kourouthanassis et al., 2015) explores the usage of mobile phone technology in daily life activities. The mobile phone technology is equipped with different applications such as maps and AR.

In this regard, after analyzing ICT-based existing projects, this study proposed a smart sensing environment based on a smart bracelet and an android app. The model of the smart environment will help to explore the cultural heritage and knowledge through ICT sensors and AR. This study provides a novel way for tourists to visit the heritage sites where they do not only visit the sites but also virtually participate in the cultural activities, interact with cultural objects through smart sensors and embedded objects. Indeed, through this approach, it will be easier to promote cultural heritage, local culture and engage people to participate in local cultural activities via AR.

**ACKNOWLEDGEMENTS**

Project LOCUS: playfuL cOnneCted rUral territorieS. The Internet of Things in the intergenerational creative production of cultural georeferenced contents [PTDC/COM-CSS/29228/2017] co-funded by FCT - Foundation for Science and Technology, through national funds, and by the European Regional Development Fund, framed in the Operational Programme for Competitiveness and Internationalisation - COMPETE 2020, under the new partnership agreement PT2020, (POCI-01-0145-FEDER-029228).

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Submitted: 15th May 2020.

Accepted: 10th July 2020.