IoT for Playful Intergenerational Learning about Cultural Heritage: The LOCUS Approach

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Abstract: LOCUS is a three-year multidisciplinary project with the goal of co-design, develop and evaluate an IoT system and understand its potential to support playful intergenerational engagement in creating and exploring cultural contents and learning about cultural heritage of rural territories from the Centre Region of Portugal, namely Amiais village, in Sever do Vouga. By implementing a playful and immersive cultural heritage tourism approach to foster Amiais' cultural and socioeconomic development, LOCUS will allow visitors to have immersive gamified experiences, by using a wearable device (bracelet) and their smartphones to interact with augmented everyday things around the village and to collaboratively learn about Amiais' culture and produce and share multimedia georeferenced contents.

1 INTRODUCTION

Due to huge advancements in electronics and wireless communication systems, mobile, pervasive and ubiquitous devices and services have been providing anytime-anywhere connectivity to the users, interlinking physical and cyber world and leading to the emergence of the Internet of Things (IoT), that has been acting as a powerful innovation driver, coming to revolutionize people and enterprises' routines (Borgia, 2014; Gonçalves, 2016; Park, et al., 2012; Ray, 2018).

IoT refers to a highly dynamic and radically distributed global infrastructure of networked physical objects. Augmented by technology, these objects became smart, gaining the ability to sense, process and communicate on the network, being able to interact with human users and other objects and to trigger actions on the physical realm (Atzori, et al., 2017; Borgia, 2014; Kortuem, et al., 2010; Miorandi, et al., 2012).

Although research has been mainly focused on IoT technical challenges, there is a growing interest on how people can interact through it, in a sociocultural and playful perspective (Darzentas, et al., 2015; Wyeth et al., 2015).

The LOCUS project is particularly interested in how playful interactions with smart objects can be designed to promote intergenerational communication, as a mean to avoid isolation of rural populations and contribute to healthy ageing, countering ageism and preventing the waste of older adults' experience and knowledge, while preserving the cultural heritage of rural territories.

Since older adults are often reluctant to use information and communication technologies (ICT) (FCT, 2013; Neves, et al., 2013), the IoT approach, by allowing the augmentation of everyday objects and routines (Brereton, et al., 2015), seems an adequate solution.

In this way, LOCUS main goal is to co-design, develop and evaluate an IoT system and understand its potential to support playful intergenerational engagement in creating and exploring cultural contents and learning about cultural heritage of Amiais village, in Sever do Vouga. Amiais is a rural space, with an aging population, that preserves ancient rural traditions, which are still practiced by the few permanent inhabitants, as is the case of the maintenance of communal threshing floors, an old gathering point for the farming communities linked to the husking of corn and the ritual of *desfolhada*,

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which are still done today. Other traditions and rituals remain alive, such as the midnight mass and singing the *janeiras*, the slaughter of the pig and the traditional *rojoada* after the slaughter.

The project also aims to propose an IoT model for the promotion of rural territories in a playful and immersive cultural heritage tourism approach. In this approach, visitors will have immersive gamified experiences, by using a wearable device (bracelet) and their smartphones to interact with augmented everyday things around the village and to collaboratively learn about Amiais' culture and produce and share multimedia georeferenced contents.

2 BACKGROUND

In an IoT-based system, smart objects became pervasive and able to provide information and services to users, through data sharing features, standardized and interoperable communication protocols and unique Internet addressing schemes (Atzori, et al., 2010; Atzori et al., 2017; Miorandi et al., 2012; Ray, 2018; Vermesan et al., 2011). These objects may possess means to sense physical phenomena, like temperature or light, thereby providing information on the current context or environment, or to trigger actions having an effect on the physical realm (actuators) (Miorandi et al., 2012). They are called smart objects because they show intelligent behaviour when interacting with other devices and operate autonomously over the internet (Paul, et al., 2016), being able to create new services, even without direct human intervention (Vermesan et al., 2011).

Borgia (2014) describes the three phases of IoT working way:

i) collection phase, referring to procedures for identifying objects and sensing the physical environment, most commonly through Radio-Frequency Identification (RFID) and sensors;

ii) transmission phase, that includes mechanisms to deliver the collected data to applications and to different external servers, requiring methods for accessing the network through gateways and heterogeneous technologies (e.g., wireless, satellite), for addressing and for routing; and, finally,

iii) process, management and utilization phase, that deals with information flow, forwarding data to applications and services, providing feedbacks to control applications and being responsible for device discovery and management, data filtering and aggregation, semantic analysis, and information utilization.

The IoT genesis is clearly utilitarian and it finds applicability in many scenarios such as cities (e.g. traffic control), homes (e.g. security systems), retail (e.g. inventory optimization), etc. Considering the "human" setting, specific IoT devices can attach to human body to enable health and wellness applications, like monitoring chronic disease or exercise, and productivity-enhancing applications, such as providing real time assistance in performing complex tasks through devices like electronic glasses and augmented reality technology (AIOTI, 2017; Manyika et al., 2015).

In a more sociocultural and playful perspective, there has been an increasing interest on how people can connect and interact through IoT and what impact it has on our lives (Darzentas et al., 2015; Girau, et al., 2017; Wyeth et al., 2015). Schreiber et al. (2013) suggests that IoT design should focus on interaction and consider shared awareness, intimacy and emotions, since objects' smartness depends on how people are able to interact with them.

On the other hand, play is a socially grounded and cultivated activity, in which learning can be undertaken without any repercussions (Huizinga, 1950), being an exploratory means for continuously updating our interpretations of concepts, objects, people and emotions and how these variables relate (Arnab, 2017). By diminishing boundaries between physical and digital spaces, IoT provide great opportunities for the use of games in non-entertainment contexts (Serious Games) (McGonigal, 2011), and of game design elements in non-game contexts (Gamification) (Deterding, et al., 2011), allowing for game-based informal learning experiences in everyday contexts (Arnab, 2017), but also for non-structured free play activities (Morrison, et al., 2011) and even storytelling (Darzentas et al., 2015).

Recently, some interesting projects and studies in these domains have been developed. Ghost Hunter (Banerjee and Horn, 2014) is an IoT interactive system to engage parents and children in a game-based activity for seeking out hidden sources of energy consumption in their homes. Messaging Kettle (Brereton et al., 2015) aims to foster social connection with a distant elderly friend or relative, by augmenting the routine of boiling the kettle to make tea. The Storytellers Project (Boffi, 2017) is a library remote reading aloud service connecting a community of older adult readers, who borrow children books and get an augmented bookmarker, to children and their families, that borrows an

augmented storyteller doll: by playing with the doll, the child requests a storytelling to the community of storytellers, which will be notified through their bookmarker, with a sound and light. The bookmarker will also capture and transmit the readers voice, that will be listen through the doll.

Some other projects and studies have been exploring how augmented and traceable objects can be enablers of memory, meaning and engaging narratives, such as Tales of Things (Jode, et al., 2013) and the study conducted by Darzentas et al. (2015) about how Wargaming Miniatures acquire data footprints.

Rural territories urge for cultural heritage preservation, both tangible culture (such as monuments, works of art, artefacts) and intangible culture (such as folklore, traditions, knowledge) (Jara et al., 2015). UNESCO (2017) states that protecting our heritage and fostering creativity is crucial to social identity and cohesion and to build open, inclusive and pluralistic societies.

The understanding that heritage is actually defined by ordinary people instead of heritage organizations and places emphasizes that heritage meanings and values emerge from dealing with artefacts, places and practices in the lived world of ordinary people, linking humans and nonhumans in chains of connectivity (Giaccardi and Plate, 2017). It is possible to list a very interesting set of projects that demonstrate how IoT can bring those connections to matter, in formal and informal cultural heritage settings.

Moving People (Power of Art House, 2015) is a guerrilla street art project in the context of which 10,010 3D refugees' miniatures were placed around Amsterdam public spaces, linking to a web page in which their stories can be read. Tales of a Changing Nation (Museum Diary, 2011) was an intervention at National Museum of Scotland that augmented 80 objects from Scotland's history with digital information and also let visitors attach personal memories do them. The EU project meSch (Petrelli et al., 2016) provides an IoT platform for heritage professionals to set up smart exhibitions, by enriching objects with digital content that can be accessed through augmented reality.

Research and Development in the role of IoT in the preservation and promotion of the cultural heritage of rural territories is globally reduced and projects in Portugal are unknown. As such, LOCUS presents itself as an innovative project, as it proposes the co-design, development and evaluation of an IoT system that incorporates and interconnects intelligent and social objects, supporting tangible and playful interactive experiences to promote the intergenerational creation and exploration of georeferenced cultural contents and learning about the cultural heritage of rural territories.

3 METHODS

The development of the project will go through 5 fundamental stages, as shown in Figure 1.

In the first stage, the main goal is to develop a holistic view and a comprehensive and descriptive understanding of the culture and everyday life of Amiais village and its inhabitants.

As such, and by employing an ethnographic approach, two researchers will live in the village, in order to:

i) uncover the culture, rituals, habits and stories of Amiais and its inhabitants;

ii) get familiar with the motivations, wishes and plans of the village's inhabitants, visitors and stakeholders;

iii) understand what people could find playful and how they might establish playful interactions with others and with objects;

iv) seek synergies with stakeholders (such as local government entities, cultural and recreational associations, schools).

Data will be collected mainly by using participant observation, semi-structured interviews and focus groups.

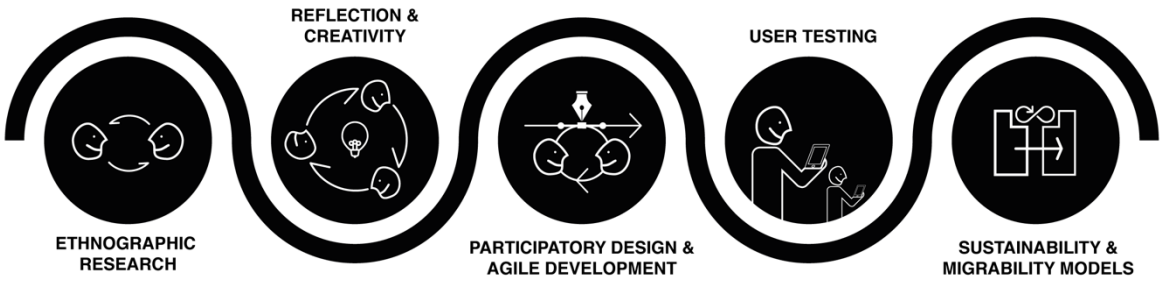

Figure 1: Stages of project development.

The following stage of the project will comprise the content analysis of transcripts of interviews and focus groups, and the hermeneutic and semiotic analysis of field journals, containing the data collected through participant observation, as well as the interpretation, discussion and consolidation of all the information gathered and knowledge acquired during the period of ethnographic immersion.

Also, during this stage, creative sessions with the inhabitants, stakeholders and visitors will be promoted, in order to discuss and consolidate the results of the analysis and to brainstorm and envision scenarios and narratives for IoT playful intergenerational experiences in Amiais village.

Based on these scenarios and narratives, the needed IoT infrastructure testbed is going to be drawn and the technical specifications for its implementation (specific network coverage, required amount of hardware and middleware, and so on) are going to be identified. Along with those, the issues concerning the technical implementation of the whole IoT system are also going to be defined, including the functional and technical requirements for the wearable device (bracelet) and the mobile App prototypes, as well as a technical feasibility study for the identification of the most suitable technologies and development platforms.

The stage three of the project development will begin with the installation of the IoT infrastructure testbed previously drafted and the development of the prototypes of the bracelet and the App. In the meanwhile, the design and development team will be formed, namely through the selection of the inhabitants, stakeholders and visitors to participate and by ensuring a high degree and quality of their participation in Participatory Design processes.

Participatory Design is about the direct involvement of people in the co-design of ICT they use and how design processes can be adjusted to embrace that involvement (Simonsen and Robertson, 2012). As the degree and quality of this participation depends on the technology potential awareness of people involved, it will be necessary the design and deliver of training sessions to foster this awareness, thus ensuring that the inhabitants, stakeholders and visitors have, in fact, a voice in the outcome.

Agile Development, on its turn, is an iterative time-boxed methodology, involving design, development and testing sprints or iterations, which imply a continuous incremental improvement of what is being developed, greatly reducing costs and time to market (Cockton, et al., 2016; Meyer, 2014).

A strategy to bring together Participatory Design and Agile Development methodologies will be assembled and tested, and it must consider the need to adapt the overly abstract representations of traditional design and development tools and processes, in order to facilitate participation, using, for example, design games, cardboard mock-ups and case-based prototypes (Simonsen and Robertson, 2012).

Sprints of design, development and testing (by the target audience through direct observation methods) will bring to life consecutive versions of the IoT system, until a final prototype version is achieved.

Once a sufficiently robust version of the IoT system prototype has been developed, it will be possible to start the user testing phase, by carrying out case studies with different user groups (children, young people, seniors, intergenerational, foreigners, etc.), for large-scale testing and evaluation of the developed IoT system prototype. According to the results of this phase, the architecture, functionalities, interaction design, content, etc., of the IoT system will be tuned.

The analysis of the data collected during these studies will also allow:

i) to understand how the individual characteristics – such as age, background, culture, digital literacy, goals, roles, 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,

ii) to develop an insight on how the physical and technological characteristics of smart objects impact playful and intergenerational interactions and collaborative exploration and creation of cultural content.

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 of the developed IoT system, to other rural territories that share cultural heritage aspects with Amiais village.

The pursuit of this goal will depend on the prior definition of the key elements to be integrated into the model, which will certainly consist of different

interrelated layers, such as a methodological layer (which may translate into guidelines, for example), a technical layer (related with the infrastructure and all the physical and logical dimensions of the IoT system), an anthropological or ethnographic layer (which will consider the particular elements of the cultural heritage) and an intergenerational communication layer (which will address the characteristics of this communication and the essential elements for its promotion).

4 EXPECTED RESULTS AND MAIN OUTCOMES

As a springboard to accomplish LOCUS' goals, a network architecture of an IoT testbed will be developed and installed in Amiais. Over this testbed, several use cases will be implemented:

i) Environmental monitoring - IoT devices will measure environmental parameters, such as light, presence of vehicles or people;

ii) Location-based information – points of interest and objects will be digitally tagged, according to playful intergenerational co-designed scenarios/narratives. When read by the users' smartphones, those tags/labels allow the distribution of georeferenced information, namely through Augmented Reality;

iii) Playful interactions - a wearable device taking the form of a bracelet with embedded sensors will be developed, to recognize accelerations, movements and rotations of the wearer's hand. The bracelet will communicate with an App, allowing that, based on the object identification and the gestures performed (shake, roll, etc.), the system may send specific feedback (playing certain sounds, asking users to perform additional actions, delivering Augmented Reality contents…). For example, the husking of corn traditions and rituals can be one of the scenarios/narratives for an IoT immersive gamified experience. Listening, learning about and producing traditional music, such as the music linked to the *desfolhada* or *janeiras* rituals, through technologically augmented instruments, is another IoT experience that can be foreseen;

iv) Participatory sensing and cultural content production – users utilize their mobile phones to send physical information (e.g. GPS coordinates) and to produce and send multimedia cultural contents (videos, sound or photos), which feed the IoT platform and can be posteriorly accessed both through the App and the online platform. Also, users can subscribe to different services, such as getting alerts for future new experiences occurring in the village.

Besides the IoT system, LOCUS will provide for the realization of a diverse set of processes, actions, contents, documents and technologies that will materialize in three more main outcomes:

i) a set of guidelines that will translate the strategy used to bring together Participatory Design and Agile Development methodologies;

ii) a Sustainability model, referring to a set of strategies to ensure the sustainability of the IoT system beyond the lifetime of the project; and

iii) a Migrability model, to guide the migration of LOCUS methodologies and IoT system to other similar rural territories (Amiais assumes itself as a prototypical village).

Additionally, the project will provide context for:

- Cultural artistic productions and creations, such as promotional multimedia and video materials to disseminate the project, inspire people and raise social awareness on the need to preserve the Cultural Heritage of rural territories; Video documentaries on Amiais' everyday life and cultural heritage; Multimedia and 3D contents (e.g., for Augmented Reality) to integrate the IoT playful and intergenerational experiences;
- The edition of a book, which will aggregate the most relevant contributions of the project for the national and international scientific community;
- The publication of research papers in peer-reviewed international journals and prestigious international scientific events proceedings, indexed in the major scientific databases;
- The organization of annual seminars, aimed at postdoctoral, doctoral and master's students, peer researchers and stakeholders, in which LOCUS's activities and results will be presented and discussed, allowing a critical analysis and evaluation of the work developed, as well as the integration of the knowledge generated in higher education activities;
- The development of pluri- and multidisciplinary masters dissertations and doctoral thesis, enabling students to develop skills and knowledge in LOCUS' intervention areas and simultaneously facilitating the project development and the achievement of the project goals.

5 CONCLUSIONS

LOCUS implements a playful and immersive cultural heritage tourism approach to foster social, cultural and economic development of portuguese rural territories, namely Amiais village, and promote intergenerational communication, as a mean to avoid

isolation and contribute to healthy ageing. By employing an ethnographically based and agile participatory design methodology, LOCUS will deliver an IoT system, which will enable Amiais' visitors to have immersive gamified experiences, collaboratively learn about the cultural heritage of the village and produce and share multimedia georeferenced contents.

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