We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900
Open access books available

185,000
International authors and editors

200M
Downloads

Our authors are among the

154
Countries delivered to

TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

Connect Smart Cities and Heritage Through Augmented Reality

Félix Labrador Arroyo, Julián de la Fuente Prieto and
Enrique Castaño Perea

Additional information is available at the end of the chapter

Abstract

This chapter aims to connect the digital resources of knowledge with the historical and cultural heritage in the context of smart cities. Specifically, combining the joint intervention in the Real Sitio of El Pardo and Aranjuez, as well as the Foundation Square of the University of Alcalá, both in Spain. Through traditional historical research and the innovative use of new technologies like augmented reality (AR), a historical, biological and cultural heritage is conserved, consisting of forests, gardens, agricultural spaces, urban centers and palatial residences. Cultural and artistic heritage is a resource of the first magnitude for the sustainable development of smart cities. It evolves with time and society; it is this that determines what goods are to be conserved and protected for posterity, according to the values attributed to them. Hence, the importance of achieving an awareness in society plays an active part in the conservation, enjoyment and dissemination of heritage. In this context, the augmented reality is presented as a powerful tool for contextualizing and disseminating the heritage, as well as to make the resources created more accessible, making an innovative use of the new technologies applied to the transfer of knowledge and the enhancement of a country's cultural and historical heritage.

Keywords: augmented reality, smart cities, heritage, royal sites, historical architecture

1. Introduction

This project, through the use of new technologies in the dissemination and transfer of knowledge to society, seeks to preserve and improve knowledge of these royal sites and the city of Alcala de Henares, of enormous environmental, cultural and educational value, constituted by forests, gardens, agricultural spaces, urban centers and palatial residences.

Thus Aranjuez or El Pardo is today the lung of Madrid, which, being a hunting ground of a royal site, escaped the relentless destruction of the natural environment that occurred as a result of the growth of the capital. It is a testimony to the landscape of yesteryear, a place where the original fauna and flora are preserved, where there is also an urban center, El Pardo, integrated into the natural space and a royal residence, El Pardo Palace, where an important architectural and artistic ensemble is preserved. Therefore, the study of the Royal Sites, in the specific case of this project of El Pardo, cannot do without considering the urban or natural environment in which these are inserted or to which they are opposed and this has to be reflected in the investigations and in the knowledge that society has of them.

Traditionally, those who have paid attention to these aspects, with great quantitative and qualitative richness, have been the art historians or architects, and the utility of them from tourism; what does not correspond, until the last years, is an equal interest on the part of other social sciences. The plurality of ways, elements and lexicons through which these enclaves, in all their components, or the spaces of power, economic development and landscape that develop in them are transformed into a multiform, polysemic sign system and modulated by different levels of perception.

Indeed, one of the great challenges we face is the impact of new technologies and their rapid evolution. According to data from the European Commission, "the global demand for ICTs is worth 2 trillion euros, but only a quarter of this amount is covered by European companies"[1], which is why it is a priority to stimulate an innovative digital society that contributes economic, social and educational benefits. No one can deny the multitude of applications they have for development in the health, architectural, social or educational field, including, for some years, the cultural. But besides being set as a factor of development, these resources have emerged as a particularly suitable means for the interpretation of cultural heritage and to transfer this knowledge to citizens and get them to identify with their past (**Figure 1**).

The architectural constructions, the urban interventions diffused or circumscribed in the territory, the more or less organic projects and the ideal city (more or less translated into practice) are an integral part of the exercise of power; they are codices constituting the authority and not ephemeral representations of it. The act of building and political action is always intimately united.

The study, enhancement and recovery of these places, shown in **Figures 2** and **3**, allow the recovery of a common past, the economic improvement of these places and their surroundings, their recovery and so on; also, they are an unbeatable space to advance the principles of an education for sustainable development, through which people acquire knowledge and skills in the field of sustainable development, which will increase their capacities and their self-confidence and increase their opportunities to opt for a healthy and productive life in harmony with nature, respectful of social values, equality between the sexes and cultural diversity, which will result in intercultural and diverse societies.

---

[1]European Commission, "Europe 2020. A strategy for smart, sustainable and inclusive growth". Brussels: Publications Office of the European Union (2010). [Accessed on March 15, 2016]. Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:ES:PDF, p. 12 and 15.

Figure 1. Past heritage in the Royal Site of Aranjuez using A.R.

Figure 2. Present heritage in the Royal Site of Aranjuez.

Indicators such as the ecological footprint, water footprint or ecological debt show that climate change, loss of biodiversity, lack of social justice, the persistence of disadvantaged social sectors, deforestation, the increase of inequalities in the distribution of wealth and so on are currently the environmental problems, that is, sociological and ecological, more importantly. We are not faced with a set of diverse problems; on the contrary, we are facing a systemic problem that obliges not only to try to alleviate its negative consequences but also to analyze and act directly on its causes.

Education alone is not enough to achieve a more sustainable future. However, without education and learning of sustainable development, we will not be able to achieve this goal. Education for sustainable development allows each human being to acquire the knowledge, skills, attitudes and values necessary to forge a sustainable future. Likewise, this sustainable education requires participatory methods of teaching and learning that motivate students and give them autonomy in order to change their behavior and facilitate the adoption of measures in favor of sustainable development.
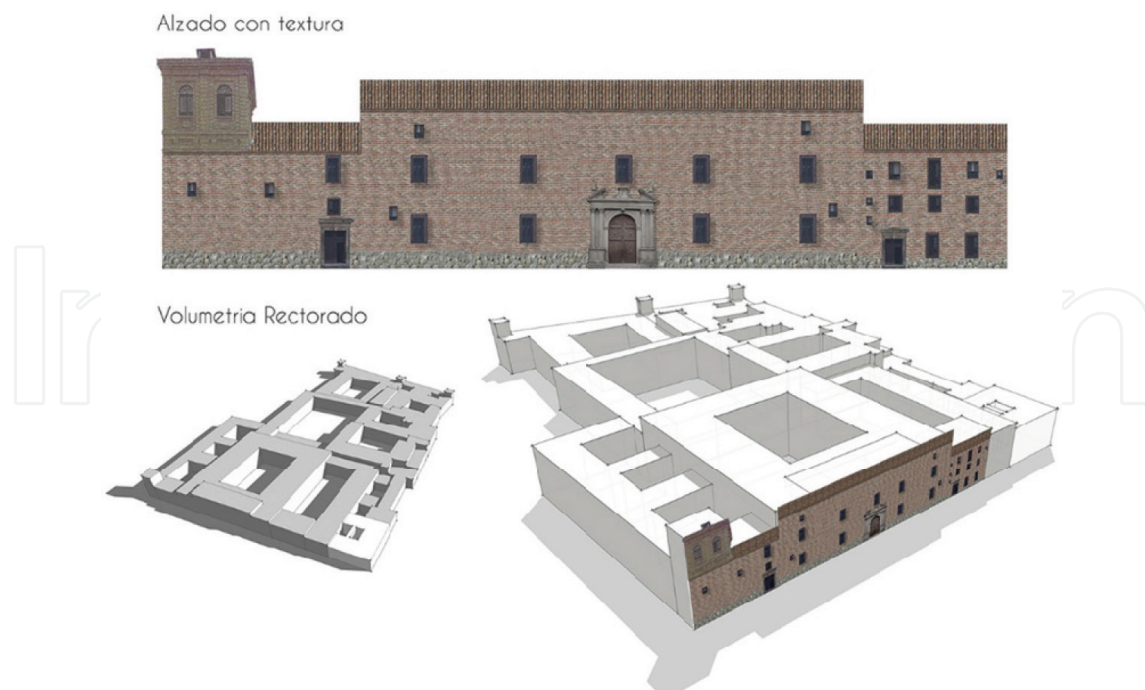
Figure 3. Virtual heritage in the University of Alcalá.

Finally, indicate that in the elaboration of this project, we have taken into account the recommendations and suggestions emanating from the document Getting cultural heritage to work for Europe. Report of the Horizon 2020 Expert Group in Cultural Heritage (2015) of the Conclusions of the Council of Europe (Education, Youth, Culture and Sports) adopted on May 20, 2014.

1.1. Goals

The main objective of this chapter is to connect digital knowledge resources with historical and cultural heritage in the context of Smart Cities. Specifically, combining the joint intervention in the Real Sitio del Pardo and Aranjuez, as well as the Foundation Apple of the University of Alcalá.

This main aim is developed through five specific objectives:

a. Creation of an environment of augmented reality of free access, showing the historical evolution of these places and the different changes that have taken place in it, highlighting the historical and cultural heritage of it, as well as the relationship with the environment and the landscape.

b. 2D and 3D interpretation of the cartography and planimetry that analyzes the process of configuration, development and consolidation of these places to the present day, which allows their better transmission and contextualization.

c. Create tourist and/or educational itineraries at various levels, accessible for the transmission of artistic, cultural and landscape heritage and value this heritage using new technologies.

d. Development of accessible didactic and educational materials with new technologies for use in Moocs or in the new realities of teaching and learning processes.

2. Theoretical framework

The theoretical framework justifies the innovative nature of the proposal. Starting from the concept of "Smart City," the technology of augmented reality is considered as the ideal instrument to develop a virtual heritage proposal.

2.1. The "smart cities" and their heritage

The concept of "Smart Cities" [1–3] is associated with the principle of sustainable urban development that includes different areas such as infrastructures, technologies or democracy. The efficiency of smart cities has an important component of social development, and there is no better way to connect a city with its population than through the heritage that unites them.

The new means of communication have generated a new field of dissemination and protection of cultural heritage [4–6] Since the declaration of UNESCO in 1972 on the preservation of material heritage and in the year 2003 on the intangible heritage, a series of processes, tools and especially networks have been generated that increase the accessibility and participation of citizens in the management of cultural assets (**Figure 4**).
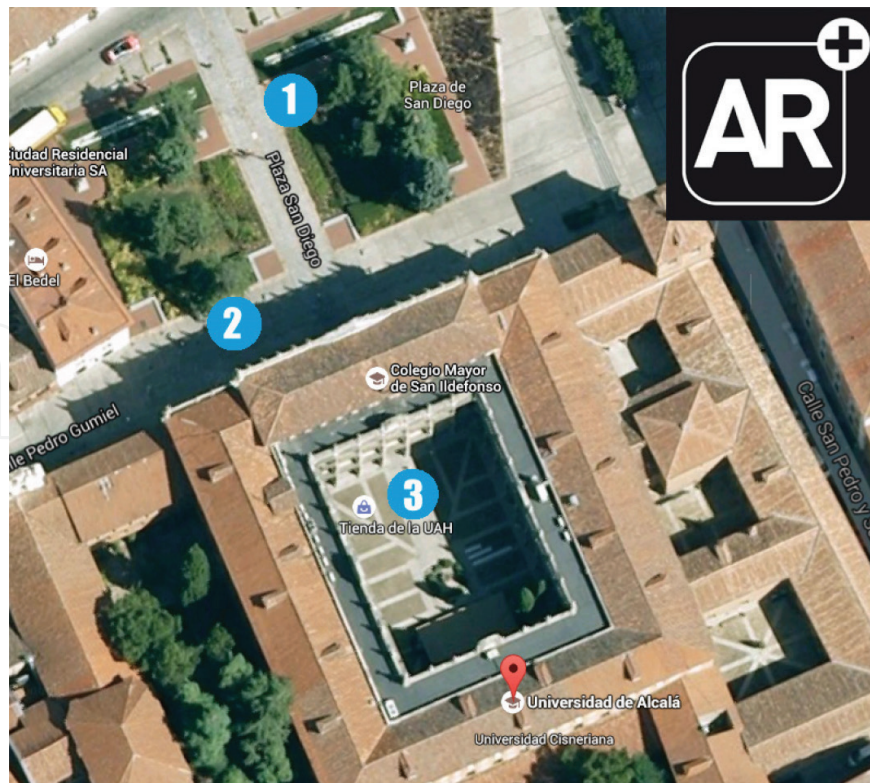

Figure 4. Identifying interested places in a smart city.

The development of a "smart city" inevitably requires efficient management of heritage, which involves its integration into new information and communication technologies [7–9]. In this sense, we now have an exceptional resource when it comes to integrating heritage in the field of these new technologies: augmented reality.

2.2. From virtual reality to augmented reality

The scope of new technologies is truly extensive and, although all of them work together for the same purpose, the truth is that here we want to make special mention of the technology of augmented reality, which has been shaping up since the last quarter of the twentieth century as a tool with great potential to transmit our past, value and raise public awareness of our heritage ([10] 5).

Computer technology has facilitated the generation of 3D objects since the beginning of the first graphic interfaces. In fact, this computing capacity has allowed the creation of complex visual environments in three dimensions for all types of applications such as videogames, geographic information systems, as well as graphic, industrial or architectural design. However, these 3D images have always needed a computer interface to be able to represent themselves. As realistic as the three-dimensional reproduction was, they always referred us to a virtual reality.

Based on virtual reality, with which it was possible to generate a fictitious environment of 360°, vertically and horizontally, of great realism for the viewer, augmented reality is, broadly speaking, a computer system that manages to mix the virtual simulated environment with a real physical scenario. To this combination, you can also add texts, documents, 2D images, audios and so on, enriching it with the information that the visitor perceives. Both present today a wide range of possibilities for different fields of knowledge, but the main difference between them is that virtual reality can or cannot be based on a real environment ([11] 25), while augmented reality only recreates a real image and needs of the visitor's on-site presence to complete the image.

The first to try to overcome this antithetical opposition between the "real" and "virtual" world were Milgran and Kishino, when formulating their model of Real-Virtual Continuum [12]. His proposal was to try to integrate real and virtual elements into a mixed reality that could be experienced in direct continuity with both worlds, real and virtual.

Through this paradigm presented in **Table 1**, a new technology derived from the application to the real world of this virtual reality began to develop in the mid-1990s, and that unlike this, it does not consist of generating virtual environments but is characterized by inserting objects or virtual spaces in a real scenario ([13] 215). It is what we know today as augmented reality and allows us to visualize 3D elements through any type of device that reproduces a real image.

This condition can be attributed to any type of montage or photo retouching, but according to Fernández Álvarez, the key to this augmented Reality is that there is a direct correspondence between the real and the virtual in terms of scale, proportion, proximity, point of view, depth and so on, which allows the user in some applications to experience the space on a natural scale ([14] 3). Therefore, we are proposing a paradigm that does not intend to recreate a new virtual world but to create a unique visual world integrated by both real space and 3D images.
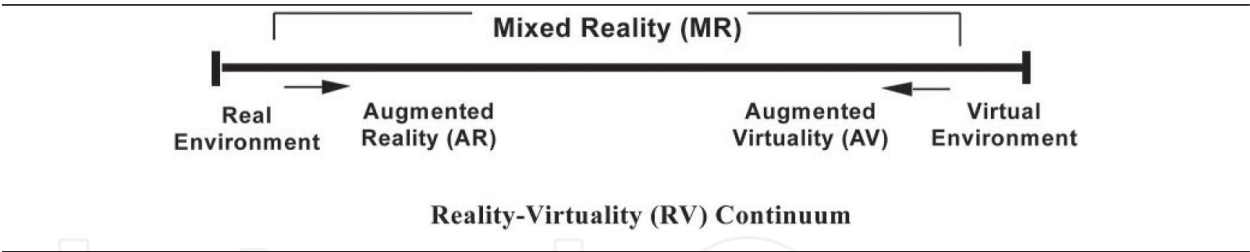
Table 1. "Reality-virtuality continuum" based on Milgran and Kishino [12].

2.3. The applications of virtual heritage

The application of augmented reality to the field of historical heritage has generated a new concept that is virtual heritage. Following the discourse of several authors [13–16], we can synthesize three approaches when using augmented reality to disseminate historical heritage:

- Reconstruction of buildings in ruins or significantly altered.

- Recreation of lost or damaged archeological pieces.

- Simulation of social or natural environments on historic sites.

To these informative functions, we must add other approaches that also consider useful in scientific contexts the generation of 3D images to simulate and investigate certain intangible material objects according to Gutiérrez and Hernández [17]:

- Test restoration techniques on synthetic models.

- Speculate with different hypotheses about lost objects.

- Analyze an archeological object in its original environment.

Therefore, it is necessary to propose new forms of content associated with this technology that go beyond the simple virtual reconstruction of historical buildings. Through augmented reality, it should be possible to enjoy new experiences that cannot occur in the real world, even in the one that has already disappeared, and that help to better understand what heritage means beyond its spatial analysis. In this sense, Gutiérrez and Hernández also defend that the incorporation of multimedia, multi-user exploration, telepresence and the possibility of showing worlds in ways that are not subject to the physical limitations of the world we live in will lead this technology to become no longer an emulation of what exists, but an expansion of our own reality ([17] 14).

This coincides perfectly with the objective of the augmented reality that according to Fernández Álvarez [14] is none other than overcoming the comprehension difficulties due to different levels of conceptual abstraction presented by the different traditional representation systems shown in **Figures 5** and **6**.

Figure 5. Virtual heritage through AR in Aranjuez.

Figure 6. Real heritage (down) through AR in Aranjuez.

3. Method

In the context indicated earlier, the augmented reality (AR) is presented as a powerful tool for contextualizing, disseminating the heritage, as well as to make the resources created more accessible. A new methodology is proposed for the organization and storage of documentation, both original and processed, from different areas and digitized and georeferenced by categorized strata: time, originality of information, scope [20, 21]. A wicker on which to deposit the documentation in an orderly and rational way for optimal management and storage.

To do this, it is proposed to use the augmented reality technology as a hub and documentation connection vehicle (from different times, types and areas), georeferencing it to the place and allowing holistic, more extensive, deep and rigorous knowledge of the heritage. Thus, a model applicable to the different scales of approach (territorial, urban, architectural and interior or domestic) and transferable to different architectural models, which allows finding new relationships between different documents that will allow in some cases verify or discard hypotheses about states and previous times [23]. Also helping to advance in a rigorous way

in the research on heritage, focusing on this project on the evolution and its relationship with the surrounding territory.

The RA together with this new work methodology will allow a selective adaptation of the information shown, in terms of quantity, rigor and complexity according to the purpose or audience to which it is shown, facilitating the understanding of the heritage in an individual and personalized way to age, level of specialization or interest [22]. This point is essential as a tool for disclosure and dissemination of heritage, as shown in **Figure 7**.

To this main objective, a new research parameter is added: the graph. To make possible the understanding of the proposed information model, it is essential to search for a graphic language capable of giving a coherent and effective response to the proposed new order, facilitating its understanding. A language that allows the visualization of variable parameters and complex relationships between different layers of information, in an affordable way. A form of graphic expression halfway between representation and communication that naturally incorporates the advantages and opportunities offered by new technologies, especially the augmented reality, together with knowledge and classical historical research.

In addition, will be made, in order to have the necessary documentation and combining and mixing new technologies with classical systems, a dump of published documentation on these places of different archives and libraries in order to agglutinate a documentary corpus that allows to visualize the evolution of this real site throughout history and the faithful reproduction in augmented reality. In this sense, we will work, fundamentally, in the General Archive of Simancas (Valladolid), General Palace Archive, National Library and National Geographic Institute and the Municipal Archives of Spain.

Indicate, in this point, that the work developed by the research team of the URJC in recent years on the study of the court, houses and real sites from the fifteenth to the eighteenth century, allows to make feasible the work proposed by the work and analysis already done.

Figure 7. Visualization of virtual heritage through RA.

4. Results

The product and final result of the project is the elaboration of a portal of augmented reality, of free access, showing the historical evolution of these places and the different changes that have taken place in it, highlighting the historical heritage, cultural identity, as well as the relationship with the environment and the landscape, with a 2D and 3D interpretation of the cartography and planimetry of these places, analyzing the process of configuration, development and consolidation of the real site until our days, as well as the creation of an augmented reality environment that allows its better transmission and contextualization (**Figure 8**).

The dissemination plan of the augmented reality application is designed to offer an innovative tool that can be integrated into previous and subsequent strategies to disclosure heritage: Some of the activities proposed are the following:

• This application may be available to the society and to the university community in particular through the services of applications for mobile devices.

• This web portal and the technology contained in it will also allow the development of materials and teaching resources in virtual environments that allow students of compulsory and university education the acquisition of competences and transferable skills.

• The content will also be used for the development of tourist itineraries in virtual environments, accessible for people, which will give value to the transmission of artistic, cultural and landscape heritage. The Visitors Service of the UAH could also have the application to improve the experience of tourists visiting the Rectorate building.

• The graphic materials and 3D models generated can be used both by the publications service and by the communication service of each university. These contents may also be transferred to third parties for tourist or cultural use.

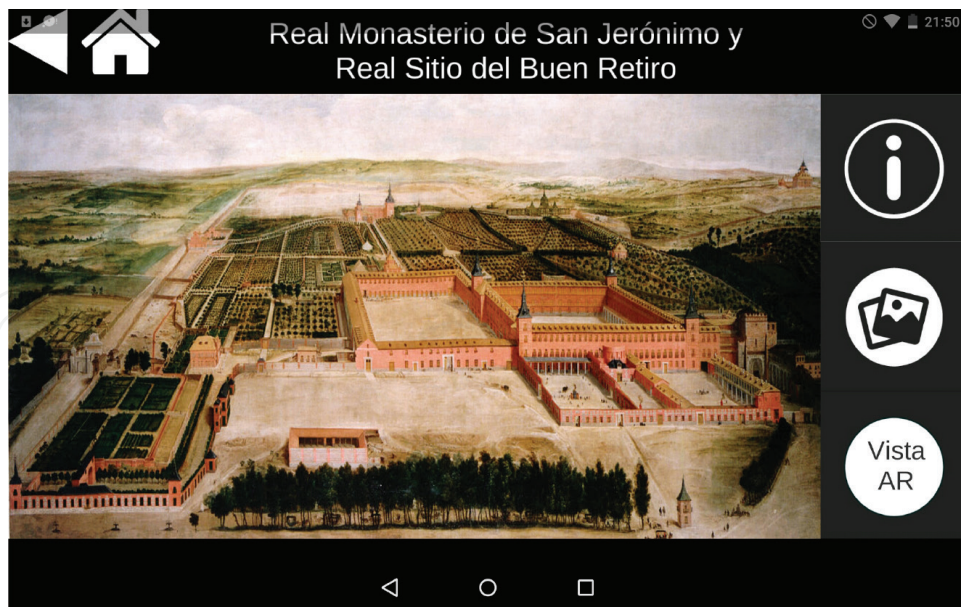**Figure 8.** Augmented reality app designed for the University of Alcalá.

Figure 9. Screenshot form the app designed for the Royal Sites (URJC-44creens.Fr).

Figure 10. Screenshot form the app designed for the Aranjuez (44creens.Fr).

- This web portal will incorporate a documentary and literary corpus on the royal site that helps to understand and contextualize its evolution. These digital documents will also be deposited in the corresponding digital repositories through the library services of both universities.

- Given the uniqueness of the experience carried out, the results of the research project will be published and disseminated jointly through international congresses as well as impact academic journals.

- This project also has a precedent in the use of augmented reality for the dissemination of heritage through several Madrid universities, which is the "Campus Husso Digital" project. The developed contents are susceptible to be included, completing this application.

Taking into account all these proposals and far from being configured as a closed activity, it is proposed that this project continues to develop through the synergies established between both research groups [18, 19] (**Figures 9** and **10**).

5. Conclusions

The concept of heritage is something subjective and alive. It evolves with time and society, that it is, in short, who determines what goods are to be conserved and protected for posterity, based on the values attributed to them. Hence, the importance of achieving an awareness of society is an active part in the conservation, enjoyment and dissemination of heritage, and that can only be achieved through knowledge. The key is how to get that knowledge to society.

Although the definition of heritage in its historical and artistic sense dates back to the Renaissance from the perspective of its study, the current concept of heritage is only established from the twentieth century, in which no longer called monuments, only works built and of historical artistic value, to also incorporate other types of goods, material and immaterial that constitute the reflection of a culture, include digital heritage depicted
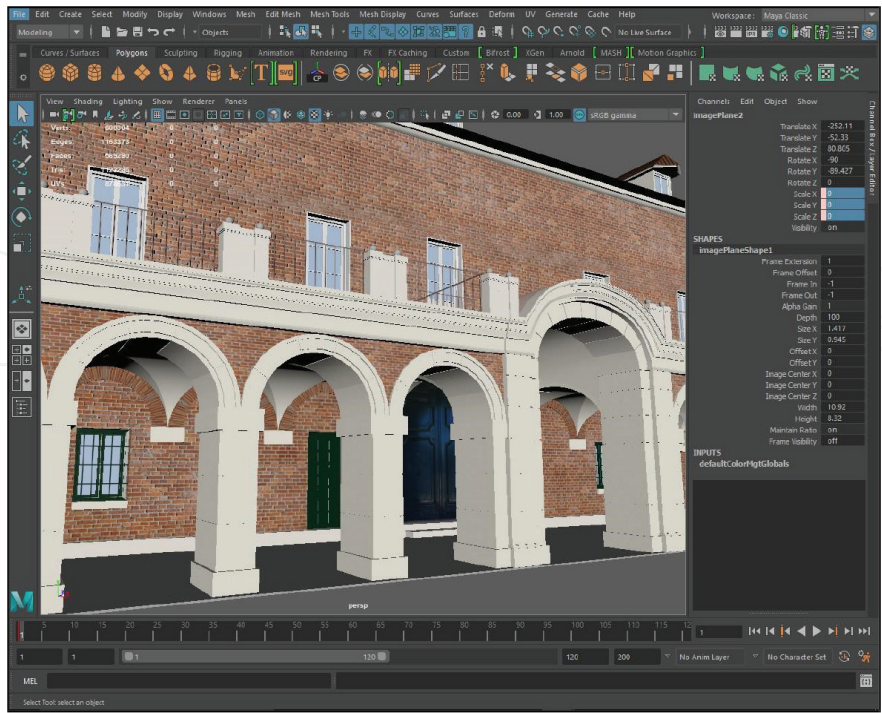

Figure 11. Screenshot of the three-dimensional model of the casa de Oficios y caballeros (David Beltrán Vizcaino).
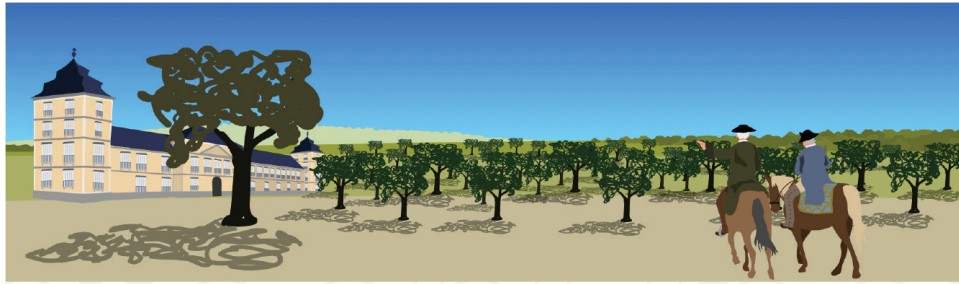
Figure 12. Animated video for children about (Manuel Álvaro Mora).

in **Figure 11**. This consideration greatly expands the scope and amount of assets to be conserved, protected and maintained. This fact, linked to the current economic context, makes the safeguarding of heritage an increasingly difficult task for which it is essential to have effective management and dissemination tools and of course support and help of the public.

It is at this point, where education and communication play a fundamental role in the dissemination and understanding of heritage from a holistic view, within the historical and social context on which it bases its value. New ways of research and transdisciplinary work are opened around the way of contextualizing, communicating and disseminating heritage, pointing out interesting synergies between the different areas that affect the understanding of that heritage: architecture, art, history, society, politics, geography and so on.

In the same measure, the way to show that information to society is fundamental is through a clear, direct and rigorous graphic language. To do this, we must take into account the evolution of technology and its impact on the visual environment, taking as reference also the field of architecture, language and tools used in the world of communication, shown in **Figure 12** (user-based design, narrative, etc.). In this context, the augmented reality is presented as a powerful tool for contextualizing, disclosure and disseminating the heritage, as well as to make the created resources more accessible.

Author details

Félix Labrador Arroyo[1]*, Julián de la Fuente Prieto[2] and Enrique Castaño Perea[3]

*Address all correspondence to: felix.labrador@urjc.es

1 Dpto. CC. de la Educación, el Lenguaje, la Cultura y las Artes, CC. Histórico-Jurídicas y Humanísticas y Lenguas Modernas, Universidad Rey Juan Carlos, Madrid, Spain

2 Dpto. de Filología, Comunicación y Documentación, Universidad de Alcalá, Alcalá de Henares, Madrid, Spain

3 Dpto. de Arquitectura, Universidad de Alcalá, Alcalá de Henares, Madrid, Spain

References

[1]   Caragliu A, Del Bo C, Nijkamp P. Smart cities in Europe. Journal of urban technology. 2011;**18**(2):65-82

[2]   Chourabi H, Nam T, Walker S, Gil-Garcia JR, Mellouli S, Nahon K, Scholl HJ, et al. Understanding smart cities: An integrative framework. Paper presented at the system science (HICSS), 2012 45th Hawaii international conference on. 2012

[3]   Schaffers H, Komninos N, Pallot M, Trousse B, Nilsson M, Oliveira A. Smart cities and the future internet: Towards cooperation frameworks for open innovation. Future internet assembly. 2011;**6656**(31):431-446

[4]   Din H, Wu S. Digital Heritage and Culture. Hackensack, NJ: World Scientific; 2014

[5]   Grana C, Cucchiara R. Multimedia for cultural heritage : first international workshop, MM4CH 2011, Modena, Italy, May 3, 2011 : revised selected papers. New York: Springer; 2012

[6]   Ioannides M. Heritage in the Digital era. Brentwood, Essex: Multi-Science Publishing; 2010

[7]   Bentkowska-Kafel A, Denard H, Baker D. Paradata and Transparency in Virtual Heritage. Burlington, VT: Ashgate; 2012

[8]   Shumaker Re, Lackey Se. Virtual, augmented and mixed reality : designing and developing virtual and augmented environments : 6th international conference, VAMR 2014, Held As Part of HCI International 2014, Heraklion, Crete, Greece, June 22-27, 2014 : proceedings. 2014

[9]   Zhou M, Geng G, Wu Z. Digital Preservation Technology for Cultural Heritage. New York: Springer; 2012

[10] Gómez Robles L, Quirosa García V. Nuevas tecnologías para difundir el Patrimonio Cultural: las reconstrucciones virtuales en España. en Revista Electrónica de Patrimonio Históric. 2009;**9**

[11] López Pombo H. Análisis y Desarrollo de Sistemas de Realidad Aumentada. Madrid: Universidad Complutense. Proyecto Fin de Máster en Sistemas inteligentes; 2010

[12] Milgram P, Kishino F. A taxonomy of mixed reality visual displays. en IEICE Transactions on Information Systems. 1994;**E77-D**(12)

[13] Ruiz Torres D. Realidad Aumentada, Educación Y Museos. en Icono 14. Año 9. 2012;**2**: Pág. 212-226

[14] Fernández Álvarez AJ. De las arquitecturas virtuales a la realidad aumentada: un nuevo paradigma de visualización arquitectónica. en: Actas del X Congreso Internacional de Expresión Gráfica aplicada a la Edificación. 2010

[15] Flores Gutierrez M. (2011) "Visor de Realidad Aumentada en Museos (RAM) para Exposiciones Situadas en Entornos Cerrados" en Virtual Archaeology Review. N° 3. Pág. 87-91

[16] Gil T, Santacana J. De lo real a lo digital: la arqueología reconstructiva y la obtención de imágenes virtuales para la investigación en la didáctica del patrimonio. en HER&MES N. 2013. 13. Págs. 16-35

[17] Gutiérrez D, Hernández LA. Potencial de la realidad virtual en el ámbito del Patrimonio. Universidad de Zaragoza; 2003

[18] Castaño Perea E, de la Fuente Prieto J. The future of augmented reality in architecture: From real to virtual heritage. In: Castaño Perea E, Echeverria Valiente E, editors. Architectural Draughtsmanship: From Analog to Digital Narratives. Cham: Springer International Publishing; 2017. pp. 1745-1753

[19] de la Fuente Prieto J, Castaño Perea E, Labrador Arroyo F. Augmented reality in architecture: Rebuilding archeological heritage. International Archives of the Photogrammetry Remote Sensing and Spatial Information Science. 2017;**XLII-2/W3**:311-315. DOI: 10.5194/isprs-archives-XLII-2-W3-311-2017

[20] Alonso N et al. Análisis de escenarios de futuro en realidad aumentada. Aplicación al yacimiento arqueológico de Els Vilars. En AA. VV. Actas del 2° Congreso Internacional de Interacción Persona-Ordenador (Interacción'2001), Salamanca. 2001. pp. 16-18

[21] Blasco Senabre J et al. (2011) "Procesos de documentación arqueológica y generación de modelos virtuales" en Virtual Archaeology Review. N° 3. Pág. 65-70

[22] Redondo Domínguez E. (2012) "La ciudad como aula digital. Enseñando urbanismo y arquitectura mediante mobile learning y la realidad aumentada" en ACE: Arquitectura, Ciudad y Entorno N°.19. Pág. 27-54

[23] Rivera Blanco J. Restauración Contemporanea. Ciudades universitarias, ciudades Patrimonio de la Humanidad. La manzana fundacional cisneriana de la Universidad de Madrid: Universidad de Alcalá. 2013. 652 p. ISBN: 978-84-15834-04-5