



# DESIGN OF A VIRTUAL TOUR FOR THE ENHANCEMENT OF LLÍRIA'S ARCHITECTURAL AND URBAN HERITAGE AND ITS SURROUNDINGS

## DISEÑO DE UN TOUR VIRTUAL PARA LA PUESTA EN VALOR DEL PATRIMONIO ARQUITECTÓNICO Y URBANO DE LLIRIA Y SU ENTORNO

José Miguel Maicas, María José Viñals\*

Departamento Ingeniería Cartográfica, Geodesia y Fotogrametría, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain. [jomaipra@hotmail.com](mailto:jomaipra@hotmail.com); [mvinals@cgf.upv.es](mailto:mvinals@cgf.upv.es)

### Abstract:

The Information Technology and Communications (ICT) have revolutionized the way to present and promote the heritage sites. These ICT also offer scholars, students and visitors unprecedented access to architectural, historical, geographical, archaeological, iconographical and anthropological data, among other. It is noted also that virtual heritage environments are inherently fascinating and possess essential properties to have a positive effect on supporting heritage conservation and education. This paper is concerned with the potential of these ICT developments for improving the enhancement of the heritage sites of the town of Lliria and its surroundings (Valencia, Spain) by mean of a virtual tour ("Edeta 360°") based on 360° panorama photos. The "Edeta 360°" virtual tour is an immersive application that places the viewers inside the image, enabling them to significantly enhance position awareness and providing the highest level of functionality for viewing, capturing and analysing virtual data. It can appropriately and effectively be utilised to facilitate intellectual and physical access to public by bringing knowledge, awareness and appreciation about the heritage of Lliria while, at the same time, authenticity is preserved. The undertaking method to create this interactive virtual tour is based on an easy procedure with off-the-shelf equipment and using both freely available software to address the process of photo stitching that combines multiple photographic images with overlapping fields of view to produce a segmented panorama or high-resolution image. Each panorama contains hotspots that enable the users to further explore the surroundings. The virtual tour provides the user the ability to navigate a scene through the rotation and zoom functions. This application results very appealing and has been adopted as a mean for information, dissemination, education and tourism purposes.

**Key words:** ICT and cultural heritage, virtual tour, panoramic images

### Resumen:

Las Tecnologías de la Información y la Comunicación (TICs) han revolucionado la manera de presentar y promover los lugares patrimoniales. Las TICs ofrecen la posibilidad a académicos, estudiantes y visitantes de acceder, como nunca antes había sucedido, a información arquitectónica, histórica, geográfica, arqueológica, iconográfica y antropológica. Hay también que resaltar también la fascinación y los efectos positivos que los ambientes virtuales desempeñan en la conservación y la educación. Este artículo se centra en el potencial que tienen las TICs para mejorar la puesta en valor de los elementos patrimoniales de la ciudad de Liria y sus alrededores (Valencia, España) gracias al desarrollo de un tour virtual ("Edeta 360°") realizado a partir de fotografías panorámicas de 360°. El tour virtual "Edeta 360°" es una aplicación inmersiva que sitúa al observador dentro de la imagen, permitiéndole tomar conciencia de la situación de forma significativa y proveyéndole de un alto nivel de funcionalidad para poder ver, capturar y analizar los datos virtuales. Esta aplicación es apropiada y eficiente para facilitar el acceso intelectual y físico al público ya que fomenta el conocimiento, la concienciación y el aprecio por el patrimonio de Liria, a la vez que preserva la autenticidad del lugar. El método utilizado para llevar a cabo este tour virtual interactivo se ha basado en un procedimiento sencillo, utilizando equipamiento propio y software libre que combina múltiples imágenes fotográficas superponiendo campos de visión para producir una imagen de alta resolución. Cada panorama contiene puntos de interés que permiten al usuario explorar en detalle los alrededores. El tour virtual brinda al usuario la posibilidad de navegar en la escena a través de las funciones de rotación y zoom. Esta aplicación resulta muy atractiva y ha sido adoptada como medio de información, divulgación, educación y turismo.

**Palabras clave:** TICs y patrimonio cultural, tour virtual, imágenes panorámicas

## 1. Introduction and objective

In the last few decades, numerous studies have researched into how to apply Information and Communication Technologies (ICT) to cultural heritage (i.e. Monod & Klein, 2005; Styliaras, Koukopoulos & Lazarinis, 2010; Hermon & Kalisperis, 2011; Ott & Pozzi,

2011; Rogerio-Candelera, 2014), with special attention given to architectural heritage and urban spaces.

More recently, with the development of spatial simulation and visualisation tools for spaces that cannot be accessed easily, several applications have focused on studying immersive and realistic forms of communication

\*Corresponding author: María José Viñals, [mvinals@cgf.upv.es](mailto:mvinals@cgf.upv.es)



which provide public access to the contents of cultural heritage. According to Niccolucci (2002), virtual heritage productions may be ideal in responding to a need for a fashionable synergy between scientific enquiry, technology, art, and everyday life, and, consequently, influence more serious cultural demand.

Among these applications, virtual environments have been widely used in the field of cultural heritage. They allow the general public to appreciate remote (in space and time) cultural assets with an immersive experience. This is the case of many virtual museum applications (Styliania, Fotisb, Kostasa, & Petrosa, 2009; Miguélez Fernández, 2013; Reffat & Nofal, 2013), which offer the opportunity to explore a remote site by manipulating (rotating, enlarging, etc.) fragile precious objects with no risk of damaging them. It is also the case of archaeological sites, where reconstructing damaged structures or remains allows users to gain a realistic overall vision of the ancient buildings (e.g. Rodrigues, Magalhaes, Moura, & Chalmers, 2008; Ercek, Viviers, & Warzée, 2010; Guidi, Russo, & Angheleddu, 2014).

Among the different virtual approaches, virtual tours (VT) are one of the most popular productions (e.g. Bastanlar et al., 2008; Wessels, Ruther, Bhurtha, & Schröder, 2014).

A virtual tour consists of a panoramic photography application that allows users to use a mouse to interact with the panorama by, for example, rotating it in all directions, from the floor to the ceiling, to go from one room to another, to zoom on the image, etc. Additionally, multimedia information and hyperlinks can be incorporated in order to provide more in-depth information so that the final presentation is enriched.

This kind of application is currently being used extensively around the world because it is able to provide views of a wide variety of spatial data (realistic vision of building and surroundings) in a single environment, and to do so in a very attractive, interactive and meaningful way, thereby facilitating site cognition and learning.

The objective of this paper is to describe the work undertaken to create an interactive virtual tour based on panoramic photos for the town of Lliria and its surroundings, called "Edeta 360°" (the name of the old Iberian town).

This work is a practical application developed within the framework of the International Postgraduate MSc Programme "Building Heritage Conservation" at the *Universitat Politècnica de València*. It represents a case study of the use of technology that aims to provide the general public with access to Lliria's heritage, thereby enabling them to learn about it and appreciate it. At the same time, it serves as a mean to disseminate and share the wide and rich heritage of this municipality, and to engage users in a real experience of the town of Lliria.

It has, at all times, followed the London Charter for the Computer-Based Visualisation of Cultural Heritage (2009), which establishes internationally-recognised principles for the use of computer-based visualisation by researchers, educators and cultural heritage organisations<sup>1</sup>.

## 2. The town of Lliria and its surroundings

Lliria, the county town of the Camp de Turia, is located 25 km away from Valencia between the Mediterranean coastal strip and the Iberian mountains. The municipal district covers an area of 228 km<sup>2</sup>, being one of the largest in the province.

This strategic location has favoured the settlement of several historical civilisations going back to pre-Roman times (at least the second millennium BC). Archaeological remains of all of these civilisations (Iberians, Romans Visigoths, Byzantines, Muslims and Christians) are scattered throughout the entire municipal district and many of them are also concentrated in the historical town itself.

Previous work was done in this issue (Maicas & Viñals, 2016). Currently an extended version of the application is presented. Edeta 360° focuses on the process of virtualisation of the historical buildings located in the historical town of Lliria, without excluding the possibility of extending the study area in further works.

The decision to utilise ICTs was justified by the imbalance that existed between the large number of heritage assets to be managed and the limited staffing resources. This makes it impossible to keep all the monuments open with a regular schedule for visits. Another factor, as mentioned earlier, is the geographical dispersal of the assets in a large district, which also forces the Town Council to keep many sites closed to the public.

Additionally, accessibility is affected by difficulties related to the urban topographical features (slopes, grades, etc.), and also because the private owners of some historical buildings do not allow visitors on their properties. On the other hand, many old buildings also offer difficulties when it comes to accessing certain rooms, such as the bell towers, upper floors, etc.

## 3. Methodology

There are different ways to create a 360° virtual tour. This work employs the easiest procedure in order to use off-the-shelf equipment and mostly freely available software, while still ensuring the quality of the final product. The simulation environment is based on the same concept as that used by Google Street View; namely, it consists of a set of spherical images that capture the whole environment around the data collection point where they are performed.

The selection of the different heritage assets and/or environments was the first step in the elaboration of the virtual tour. The criteria applied to select these heritage elements were primarily: significance, singularity, representativeness and uniqueness, but also physical accessibility.

Thus, eighteen visitable cultural assets (Fig. 1) were included in the virtual tour. These cultural assets are already recognised as "Assets of Cultural Interest" (Bienes de Interés Cultural – BIC) by the Spanish national heritage protection law and they are also "Assets of Local Relevance" (Bienes de Relevancia Local – BRL) in accordance with regional law. All of them are protected by the Llirian Urban Planning Programme (Catálogo de Bienes y Espacios Protegidos del Plan General de Ordenación Urbana – PGOU).

<sup>1</sup> <http://www.londoncharter.org/> (Accessed January 13<sup>th</sup>, 2016)

- |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Vila Vella</b></p> <ul style="list-style-type: none"> <li>• Ayuntamiento de Llíria, Casa Consistorial (Ca la Vila)</li> <li>• Baños Arabes</li> <li>• Horno de Pancocer (Forn de la vila)</li> <li>• Iglesia del Buen Pastor (Hospital medieval)</li> <li>• Iglesia de la Sangre</li> <li>• Parroquia de la Asunción de Nuestra Señora</li> <li>• Iglesia de Nuestra Señora del Remedio</li> <li>• Iglesia de la Mare de Déu</li> <li>• Muralla Medieval de Llíria</li> </ul> <p><b>Tossal de Sant Miquel</b></p> <ul style="list-style-type: none"> <li>• Poblado Ibérico Cerro San Miguel, Edeta</li> <li>• Real Monasterio de San Miguel</li> </ul> <p><b>Edeta romana</b></p> <ul style="list-style-type: none"> <li>• Colegio San Vicente Ferrer</li> <li>• Mausoleos Romanos</li> </ul> <p><b>El "Raval"</b></p> <ul style="list-style-type: none"> <li>• Almudín</li> <li>• Ermita de Santa Bárbara</li> <li>• Parroquia de San Francisco de Asís</li> </ul> <p><b>El "Pla de l'Arc"</b></p> <ul style="list-style-type: none"> <li>• Ermita de San Vicente (Santuario de San Vicente)</li> <li>• Parroquia de María Madre de la Iglesia</li> </ul> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Figure 1: List of the Llírian cultural assets included in the virtual tour.

Secondly, all information related to these assets was recorded from documentary and bibliographic sources (digital, graphical and written materials), so that they could be enhanced virtually. This material includes aerial images of the town, old pictures, historical texts, artistic drawings, etc.

Another task was to carry out walks around the territory and the town in order to become familiar on a first-hand basis with the reality of the selected heritage assets.

The steps followed in the process of developing the virtual tour are described below.

### 3.1. Taking photos

The purpose of this task is to create the panorama view by applying 360° photography techniques in order to capture the entire surroundings of a location.

To this end, at each cultural asset a central shooting position was established to guarantee the same focal length and taking into account the radius on which it will swing so as to ensure there was enough image overlap (at least 25-30%) to allow the photos to be stitched together, as suggested by Fangi (2006). The spherical coordinates are established with a radial distance ( $r$ ) and two angles ( $\phi$ ,  $\theta$ ), as depicted in Figure 2. The radius has to be as small as possible; the first angle ( $\phi$ ), with an opening of 0° to 360°, rotates in a horizontal plane. The third coordinate is another angle ( $\theta$ ) with a value ranging from -90° to 90° in the vertical plane.

The number of shots in this case study was very high because fisheye lens are not used in this procedure. The images did not contain any moving objects or people because these could cause errors in the scene.

Photographs were taken based on the coordinates 0.1, 0°, -90°; namely, a small radius pointing in the main direction and at the floor. From here, the third coordinate at 30° was increased to complete the 180°. After this arc

of circumference, it begins another turn of 30° from the main direction, and so on successively until the circumference is completed.

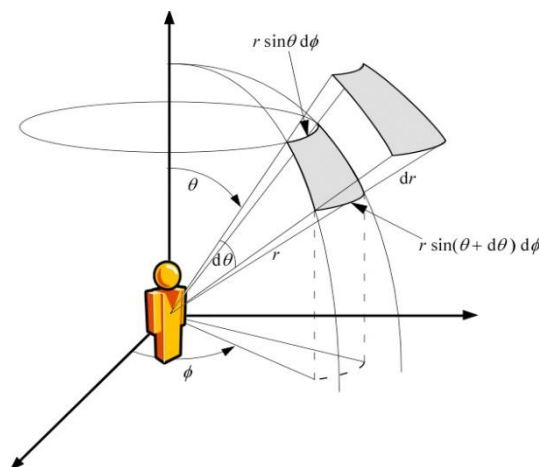


Figure 2: Spherical coordinates (radius and two angles).

A total of 6,000 photos of Llíria were captured during 12 field campaigns between January and June 2015.

The result of this procedure is a spherical photo-mosaic, which consists of the retroprojection of the photographs on a spherical surface. In our case, 70 panoramas of Llíria were created, which is a number that is sufficient to create a fluid route. Additionally, 20 aerial images from Google Earth and Iberprix were imported to create site maps.

### 3.2. Rendering the spherical images onto flat 2D surfaces

First of all, some photo edits or corrections were performed; then, luminosity and colour-level adjustments were made in order to obtain homogeneous images, and optical lens distortions were also corrected.

The most commonly available rendering options for virtual tours, according to Ippoliti, Calvano & Mores (2014), are spherical geometric projections (also called equirectangular projection). This is really a cartographic representation that consists in transposing points of the sphere onto a straight cylindrical surface imagined to be tangent to the sphere at its greatest parallel.

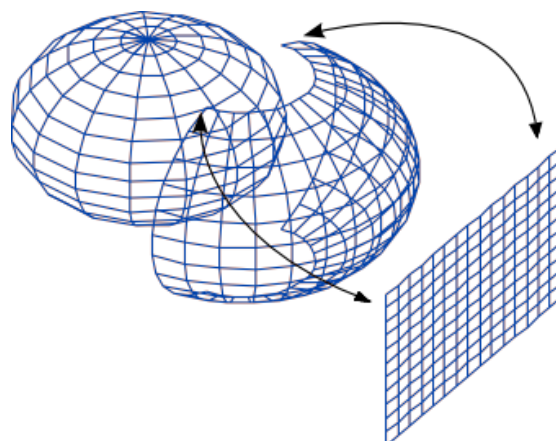


Figure 3: Texture overlapped onto a sphere.





Figure 4: La Mare de Déu texture 360°.

### 3.3. Stitching photos to create 360° panorama images

This was made performed by using the open source panorama stitcher HUGIN 2014.0.0, developed by Pablo d'Angelo. This is a freely available software application that is licensed under the GPL, and runs on Microsoft Windows® and GNU/Linux®. This program imports the photos into a raster-based application, superimposes them two by two, and generates a single panoramic image of the deployed sphere that can be mapped onto planar surfaces. In these images, like a flat map of the Earth, the most remote areas are highly distorted; the image will only be seen properly when the texture is overlapped on a sphere as seen in Figure 3.

The final result of this procedure was a collection of high quality 5000 x 2500 pixel images (Fig. 4). This is an acceptable resolution that allows distant elements to be zoomed in on without loss of quality.

### 3.4. Converting a 360° panorama into a virtual tour

The panorama generated by the stitching software was imported into the Easypano Tourweaver 7.90@ software application to produce the visitable and interactive urban virtual tour. It allows the panorama to be set in motion and the creation of a navigation interface that allows users to walk through the scene virtually. Each spherical scene is connected to another by a link. With this spatial configuration, the user does not move continuously but discretely, jumping from one fixed position to the next, and having viewsheds in any direction, but from a finite number of locations (Fig. 5) because the user is confined to specific viewpoints. Nevertheless, this interactive application allows the user to take control over the panoramic visit by arranging different kinds of movements (rotation, inclination, close-ups, distancing, etc.).

To further explore the site, the visitor can move on to investigate other structures and the landscape (from one scene to another) by way of clickable invisible polygonal hot spots (opacity 0%), which will be triggered when a pointing device (usually a mouse) is moved over another heritage element whether visual contact exists between them. The images to be connected can be both exterior

and interior. In order to contemplate the building from different angles, the spheres needed to be able to walk around were constructed. Afterwards, the interior of the building can be visited. The spheres are connected consistently, and the inside of the building can only be accessed through a sphere that includes a door.

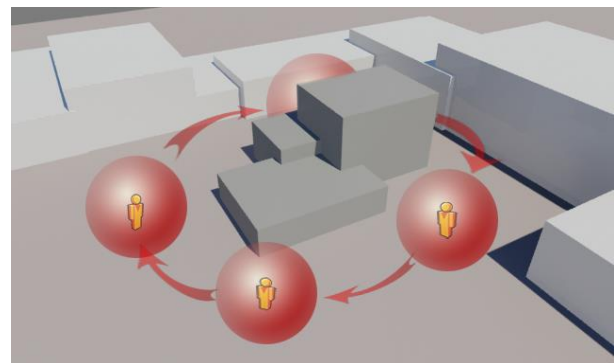


Figure 5: Locations of spheres.

### 3.5. Adding extras to the virtual visit

Navigation instruction texts, heritage information documents (different plans showing the evolution of the building over time, documentary texts, etc.), audio files, images (old pictures, etc.) are included in the application as pop-up windows. This information enriches the virtual tour, allowing visitors to gain more comprehensive knowledge about each heritage asset.

## 4. Results: Appearance of Edeta 360°

Edeta 360° opens when you right-click the virtual tour; it then shows a contextual menu (Fig. 6).

The second screen displayed consists of an introductory text (Fig. 7) with instructions on how to navigate and which also invites the user to enter.

After clicking on the access button, navigation starts with an urban aerial photo (Fig. 8) of the historical town of Llíria and related zooming images of the different virtually enhanced heritage sites and surroundings: La Vila Vella (Fig. 9), Edeta Romana, Tossal de Sant Miquel, El Raval and Pla de l'Arc. The visitor can select

one of them by clicking on the area and, afterwards, a historical building can be chosen by clicking on it; then, a first image of the main access door of the building appears.

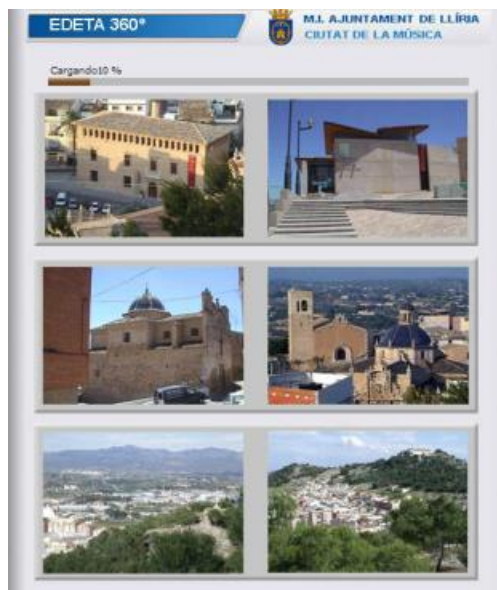


Figure 6: Edeta 360° loading screen: Contextual menu.



Figure 7: Edeta 360° introductory screen.



Figure 8: Aerial photo of the centre of Llíria.



Figure 9: Detail of historical centre La Vila Vella.

When the cursor slides over streets, doors, stairs, etc., and becomes a hand, another connected panoramic sphere can be opened if clicked on. The cursor can also be transformed without any navigation motion. This occurs if there is additional pop-up information associated with the object.

In Figure 10, the *Iglesia de la Sangre* is presented as an example (Fig. 10a), and showing the appearance of the additional pop-up panel for the Bell Tower (Fig. 10b).



(a)



(b)

Figure 10: *Iglesia de la Sangre* with Bell Tower: a) Presentation screen of the church; b) Additional pop-up window.

The building can be seen in all directions; it can be walked around or the inside can be accessed (Fig. 11). Indoor, it can also be visited virtually and in-depth information about it can be obtained by deploying the pop-up windows.

## 5. Discussion and concluding remarks

As final thoughts about the project that was developed, the following comments can be highlighted.

Firstly, it must be mentioned once again that virtual heritage environments need to possess certain essential properties to have a positive effect on the general public.

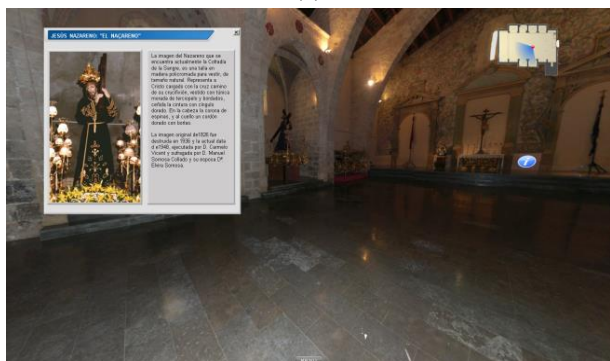
Beyond the well-established methods that have traditionally been employed in the field of cultural



## DESIGN OF A VIRTUAL TOUR FOR THE ENHANCEMENT OF LLÍRIA'S ARCHITECTURAL AND URBAN HERITAGE AND ITS SURROUNDINGS



(a)



(b)

**Figure 11:** Iglesia de la Sangre: (a) Screen with navigation options; (b) Pop-up complementary windows.

heritage to date, ICTs, and particularly virtual tours, have become increasingly more popular tools to achieve heritage enhancement, tourism experience development and dissemination. This is because virtual tours have the ability to arouse fascination far beyond a tourist brochure or any printed material. For this reason, it is a widely used application in cultural events and tourism fairs.

On the other hand, an online virtual tour can effectively contribute to the recreational experience in the sense that Viñals, Morant & Teruel (2014) noted. Hence, besides the onsite phase of visitation, the virtual tour has a high potential to generate motivation and expectations in the phase prior to the visit. A virtual online tour can also consolidate feelings of appreciation after the visit.

However, it should be noted that Lliria can be visited virtually by Google Street View, but this application does not include many of the areas shown in Edeta 360° or the interior of buildings. Other specific advantages have been identified, such as its contribution to address accessibility issues (private ownership of the heritage, physical difficulties to visit some places, etc.). This application also includes additional information such as text, audio, evolution of the buildings over time, among others.

### References

- Bastanlar, Y., Grammalidis, N., Zabulis, X., Yilmaz, E., Yardimci, Y., & Triantafyllidis, G. (2008). 3D reconstruction for a cultural heritage virtual tour system. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 37-B5, 1023–1036.
- Ercek, R., Viviers, D. & Warzée, N. (2010). 3D reconstruction and digitalization of an archaeological site, Itanos, Crete. *Virtual Archaeology Review*, 1(1), 81–85. <http://dx.doi.org/10.4995/var.2010.4794>

Additionally, another contribution of Edeta 360° is the overall vision, featuring the heritage of a destination from an urbanistic perspective rather than a view of single elements. This presentation makes it possible for the user to know all of the assets that make up the whole site. This vision is necessary to understand the history of the place and this knowledge would be temporally and spatially impossible to obtain in many tourist destinations unless offered through a virtual tour.

This panoramic tour is available online, at [www.edeta360.com](http://www.edeta360.com). Regarding the maintenance and updating of the application, it should be noted that a project based on ICTs, because of their rapid evolution, risks becoming obsolete in a short time. Therefore, it is necessary to update it regularly, not only in terms of the content but also as regards the devices from which you can access it. In this case, updates are performed by ftp, with the FileZilla program. In the last update, an app available on Play Store (Edeta 360°) was created that allows access to this content from an icon on a smartphone or tablet without having to type the URL in a browser. Another update that is being implemented at the moment is the inclusion of 360° videos, thus allowing the user to have more immersive views. These videos are also compatible with virtual reality cameras. Furthermore, to reach a larger number of users, this application would need to be translated into other languages.

On the other hand, it is noteworthy that the current approach with simple off-the-shelf equipment is an important strength of the project. It thus gives an idea of the broad potential of its extrapolation to other similar heritage assets. Moreover, it must be remembered that this process is open to possible technological upgrades and expansions in the study area, so everything carried out so far can be considered a good starting point. However, it must be recognised that it is necessary to look deeper into how to strengthen the emotional dimension of these presentations. Some authors, like Roussou (2008), have already opened up this debate. For this reason, future updates will include people, in order to better engage and empathise with the user. With all these improvements, Edeta 360° will be far more popular and appealing.

Finally, it must be noted that local heritage administrations are in the best position to lead the design of the virtual reality productions that are needed to conserve, enhance and make their heritage more dynamic because local communities are the first to benefit from these actions.

### Acknowledgements

The authors of this work wish to thank Lliria Town Council and other institutions for supporting the development of Edeta 360°. We are also grateful for the scientific peer reviewing work carried out by Dr. Cristina Portalés.

- Fangi, G. (2006). Investigation on the suitability of the spherical panoramas by Realviz Stitcher for metric purposes. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 36-5, 25–27.
- Guidi, G., Russo, M., & Angheluddu, D. (2014). 3D survey and virtual reconstruction of archeological sites. *Digital Applications in Archaeology and Cultural Heritage*, 1(2), 55–69. <http://dx.doi.org/10.1016/j.daach.2014.01.001>
- Hermon, S. & Kalisperis, L. (2011). Between the real and the virtual: 3D visualization in the cultural heritage domain - expectations and prospects. *Virtual Archaeology Review*, 2(4), 59–63. <http://dx.doi.org/10.4995/var.2011.4556>
- Ippoliti, E., Calvano, M. & Mores, L. (2014). 2.5/3D models for the enhancement of architectural-urban heritage. A virtual tour of design of the Fascist Headquarters in Littoria. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 2-5, 189–196. <http://dx.doi.org/10.5194/isprsannals-II-5-189-2014>
- Maicas, J. M., & Viñals, M. J. (2016). Edeta 360° virtual tour for visiting the heritage of Liria (Spain). Lerma, J.L. & Cabrelles, M. (eds.): *Proceedings of the Archaeologica 2.0. 8th International Congress on Archaeology, Computer Graphics, Cultural Heritage and Innovation*. Valencia, 5-7 September, 2016. Ed. Universitat Politècnica de València, 376–378.
- Miguélez Fernández, L. (2013). *Tour virtual por la red de museos de Gijón*. Tesina final de Master. Universidad de Oviedo.
- Monod, E., & Klein, H. K. (2005). A phenomenological evaluation framework for cultural heritage interpretation: from e-HS to Heideggers' historicity. *Proceedings of the eleventh Americas Conference on Information Systems*, Omaha, USA, 2870–2877.
- Niccolucci, F. (Ed.) (2002). *Virtual archaeology: Proceedings of the VAST 2000 Euroconference, Arezzo 24-25 November 2000*. Oxford: Archaeopress.
- Ott, M., & Pozzi, F. (2011). Towards a new era for cultural heritage education: Discussing the role of ICT. *Computers in Human Behavior*, 27(4), 1365–1371. <http://dx.doi.org/10.1016/j.chb.2010.07.031>
- Reffat, R. M., & Nofal, E. M. (2013). Effective communication with cultural heritage using virtual technologies. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 40-5W2, 519–524. <http://dx.doi.org/10.5194/isprsarchives-XL-5-W2-519-2013>
- Rodrigues, N., Magalhaes, L. G., Moura, J. P., & Chalmers, A. (2008). Automatic reconstruction of virtual heritage sites. *Proceedings International Symposium on Virtual Reality, Archaeology and Intelligent Cultural Heritage*. Ed. The Eurographics Association. <http://dx.doi.org/10.2312/VAST.VAST08.039-046>
- Rogério-Candelera, M. A. (Ed.) (2014). *Science, Technology and Cultural Heritage*. London: CRC Press/Balkema.
- Roussou, M. (2008). The components of engagement in virtual heritage environments. *Proceedings of new heritage: beyond verisimilitude*. Conference on Cultural heritage and New Media, Hong Kong, 265–283.
- Stylianias, S., Fotis, L., Kostasa, K., & Petrosa, P. (2009). Virtual museums, a survey and some issues for consideration. *Journal of Cultural Heritage*, 10(4), 520–528.
- Styliaras, G., Koukopoulos, D., & Lazarinis, F. (Eds.) (2010). *Handbook of research on technologies and cultural heritage: Applications and environments*. (pp. 1-592). Hershey, PA: IGI Global. <http://dx.doi.org/10.4018/978-1-60960-044-0>
- Viñals, M. J., Morant, M., & Teruel, L. (2014). Confort psicológico y experiencia turística. Casos de estudio de espacios naturales protegidos de la Comunidad Valenciana (España). *Boletín de la AGE*, 65, 293–316.
- Wessels, S., Ruther, H., Bhurtha, R., & Schröder, R. (2014). Design and creation of a 3D virtual tour of the world heritage site of Petra, Jordan. *Proceedings of AfricaGeo* (pp. 1–12).