# Accessibility and Augmented Reality into Heritage Site Interpretation

A pilot experience with visitors at the monument Lonja de la Seda in Valencia (Spain)

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***Abstract*— This paper summarizes a pilot experiment with Augmented Reality (AR) at this architectural monument declared World Heritage Site by UNESCO in 1996. The project aims to increase accessibility to this site and provide users, in this case, visitors to the place, with intuitive experience of this technology. The experience and the application are proposed as a complement to the visit in the real environment, emphasizing the site as a context for situated learning that contributes to knowledge. Comprehensive visits to world heritage sites endow them with extraordinary cultural and social value. Augmented reality was chosen to activate the visit experience of the place by providing elements that can be visualized and manipulated directly by users in the real environment of the building itself without the need for any excessively invasive equipment in this historical and artistic context. This application is proposed firstly, to resolve perceptual issues due to poor lighting, the distance from many details and access to some areas and secondly, to explain some of the more complex construction aspects. This pilot experiment aims to establish initial contact with visitors to the place in order to obtain relevant information for modifications and adjustments to improve the components designed and developed for this site.**

***Keywords; augmented-reality; accessibility; inclusive-design; heritage-sites; interactivity.***

## I. Introduction

Information and communication technologies together with technological tools for graphic and tactile representation are currently undergoing continuous development and expansion in the form of a wide variety of emerging applications in objects with multiple added characteristics. These new applications and their future possibilities open up a wide panorama for research ranging from the perceptual experiences these tools can offer to the nature of future devices that will incorporate them to interact with people.

This research presents an Augmented Reality application, based on a graphic substrate, to improve accessibility to this built heritage site. The most significant challenge in this experiment is make this technology available to visitors to the monument so they can explore and visualize building details as directly and intuitively as possible. This pilot experiment attempts to test on visitors, potential users firstly, receptivity to the whole experience and secondly, the use of the equipment which forms the system's general interface.

Augmented Reality is defined [1] as the combination of the real and the virtual, interactive in real time and can also be said to integrate the real context. With Augmented Reality it is possible to overcome certain limitations in the environment and/or users, and provide new perceptions and understanding of these places. The choice of AR technology for this site is based on a previous accessibility study [2] and the idea that this virtual reality application is less intrusive and provides the greatest opportunity for users to directly manipulate complex three-dimensional models in real space environments [3]. Augmented Reality (AR) is characterized as a technology that enables users themselves to interact with and visualize virtual models.

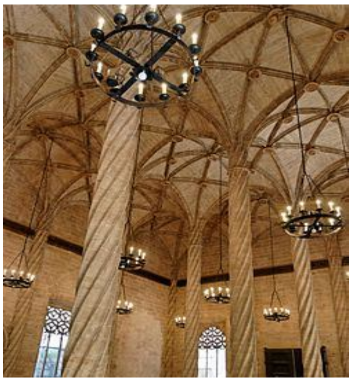

Figure 1. This pilot experiment took place in the room of columns at the Silk Exchange, Valencia. This room is the most charismatic space in the building and it characterised by its slender twisted columns.

This paper shows the role of this particular technology as mediator of a virtual representation/reality in building new ways of interacting with places and knowledge that can be useful in situations of disability.

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This tool enables a new relationship to be established between the interpretation and conservation of heritage property, permitting access to simulated perceptions that helps to overcome the common limits of visual accessibility in a specific place, due to distance, high ceilings, poor lighting or in visitors themselves: impossibility of moving towards or approaching details, reduced discrimination and visual identification abilities, etc.

The first part of this paper presents some direct antecedents of this type of application and experiments and their possibilities for accessibility. At the heart of the communication presents the AR system design and main components created for this pilot experience at this singular building. We observe interaction with users in the real scenario, their choice of the element to be observed, handling the marks and their appraisals. Finally, conclusions can be drawn firstly, from users' experience of the tool in order to correct aspects of the components which can contribute to more intuitive use. Secondly, from the experience as a contribution to accessibility to the place and its contents. To this end, visitors who had used AR to visualize some elements and understand them better completed an in situ questionnaire after visiting the site. The questionnaires were not analyzed but will be taken into account to guide the redesign of the data gathering tool itself. The redesigned questionnaire will be used in a longer implementation experiment at this site when this project has finished.

## II. Virtual reality applications for interpreting and visiting monuments

The basis for this approach is situated learning [4] which assumes that learning occurs more efficiently in a real context and that the real context becomes an important part of the basic knowledge associated with this type of learning. The use of virtual reality systems can provide interpretations, stimuli and explanatory models that adapt more closely than others to the discourse of the disciplines to which they refer. In terms of accessibility, both in situ and through virtual experiences, they have an undisputed ability to compensate, by providing perceptions for understanding and enjoyment of such places, and are obviously irreplaceable in certain situations of disability.

### *A. Augmented Reality*

AR is a field of unceasing experimentation as a technological tool at the service of three-dimensional graphic representation under constant development and expansion through a wide range of very different applications. Its ability to expand information in real environments through easy-to-use dynamic virtual visualizations can solve, among others, aspects of visual accessibility in real time [5].

Many AR applications generate different types of environments with varying requirements and spatial performance. Some of these tangible or tactile AR applications use a backlit table which can be manipulated from the surface by manually dragging elements as though it were a desktop [6]. In a particularly interesting approach, the MIT's Tangible Media group implemented interfaces linked to tangible objects in an attempt to demonstrate that interaction is more intuitive and functional when a relationship is established between the physical objects being manipulated and augmented and the computer-generated image (Ishii & Ullmer, 1997). SitePack is directly related to the area of representation and visualization of architectural models and warrants mention because of the instrumental nature of the application [7]. It was designed for exteriors and enables the combination of dynamic virtual 3-D elements to assess their impact on the real environment. Similarly, the Prisma 22 project proposes visualization of real landscape space by superimposing additional virtual content with relevant information. The portable AR21 application attempts to explain the historical evolution of heritage buildings using animations and virtual descriptions in situ.

## III. A pilot experiment with Augmented Reality at the Lonja Silk Exchange in Valencia

This section describes the first experimental application of AR designed for this site to explore the use and coexistence of the system in this singular monument as context scenario. The research focuses on interaction with users in the real environment where visitors can experience the application, identify the elements and acquire broader knowledge of the place and certain details.

This pilot experiment aims to establish initial contact with visitors to the place in order to obtain relevant information for modifications and adjustments to improve the components designed and developed for this site. These are: the marks created for visitors to identify and use, the number of elements in the experiment, each of the 3-D models created and introduced in the AR engine and which are visualized in movement on the screen. Finally, a questionnaire was used to obtain users' opinions on receptiveness, use and appraisal of the application as an accessibility tool. In this initial contact with users and visitors to the place, the aim is to obtain relevant information for any modifications and adaptations required to improve the components designed for the site.

The method for creating this Augmented Reality experience has been developed in two stages. First, the technical design of the 3-D visual models, based on selected elements from the site, and the panels which are the basic interface for expanding the chosen motifs. Second, the application was implemented in the real scenario for visitors to the building la Lonja.

### *A. Technical desin: the 3-D models and the markers*

3-D visual models were created based on selected elements from the site. There are two different types of chosen elements according to volume: fully three-dimensional construction elements (Fig 2), such as the shaft of the column, the capitals and stairs and plan-dependent elements such as windows traceries (Fig 3), doors, coffering and paving.

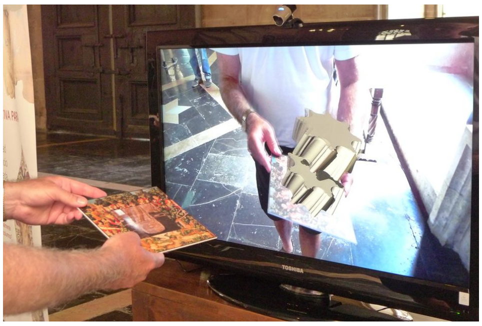

Figure 2. The model of the column is another of the elements that provide a better explanatory model of the construction.

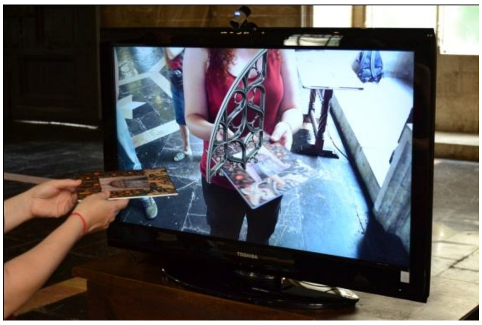

Figure 3. The proportions of the gothic traceries are particularly light and delicately related to the visualization format.

After determining the elements to be shown, three-dimensional models with representation capacity must be generated to be visualized in the AR application. These models basically consist in geometry and texture or surface [8] and there are two possible approaches [9] to generating them as three-dimensional models: data acquisition using laser scanner technology or, three-dimensional modeling of the elements based on their graphic definition.

The large quantity of descriptive graphic information on this building, together with general and partial measurements for the elements to be modeled, was considered sufficient. The models thus obtained have a low triangular load because the geometry representing them clearly and unmistakably defines the edges and apexes of the models.

To represent the textures of the models, shadows were pre-calculated and then mapped on the model as material. Shadow pre-calculation used as surface material is not intended to be a faithful imitation of the texture of the represented objects, but to conceptualize the different materials in the constructive definition. The results for model geometry and texture are sufficiently representative to show the relevant aspects of the models on the AR application.

Once the virtual 3D models where installed in the RA engine, the next decisive step for usability is to design the element that will act as intermediary in the user's experience: the markers. This interaction panels are used to trigger the loading of the different 3D models.

Considering the informative superiority of iconologies over the written word to identify actions in other interactive systems, familiar figurative references can be versatile resources for an interaction space.

The choice of graphic metaphors can help users to understand interface functionality better and improve accessibility. In an attempt to follow these considerations and bearing in mind the characteristics of this historic building, we didn't use common binary marks and it was proposed that these marks should be identified directly by users and related to the motifs they show. So, graphic formats were designed ex profeso for this site, paying particular attention to integration and comprehension. This process required some images to be retouched and the proportion of representation areas to be varied to obtain those that were finally used in the experiment.

The outcome, assessed by users, is a composition focused on a square combining photographic images with high iconic and representative value. The image that identifies the element to be visualized is in the centre, framed by another photographic image that refers to the period and what was worked with in the building, that is, silks.

These panels provide the necessary texture to be read by webcam. The proportions, size and format of these marks were pre-tested to ensure robust webcam recognition, and levels 4 and 5 were found to be optimum for the tracking technology employed. This system uses LabHuman markerless library which is based on the works of Wagner et al. [10] and Kim et al. [11]. The proposed method works fine with textured planar objects, that is, with planar images which contain a great number of keypoints. This library implemented a method based on image retrieval techniques in order to recognize simultaneously a great number of images, specifically, Nister and Stewenius [12] vocabulary tree method was used.

For this experience, 6 different panels were executed and tried. 4 of these panels have two different scales of visualization which allows more detailed information. To get this zoom in or zoom out effect user must move the markers closer or farther to the webcam.

Figure 4. Marks designed and used to activate 3D models of different details in the building.

### B. *Usage Scenario and Pilot Study*

A total of 45 individuals from different age groups and background who were visiting the monument with or without a guide, took part in this pilot experiment and completed all parts of it. The site has a constant stream of visitors throughout the year, with peak times during the summer and the cruise season (cruise ships have been stopping at the port of Valencia since 2008). At those times especially, some three thousand visitors can concentrate around the building on a single day, with a predominance of families and people over fifty. Because the project aims to validate AR technology as an accessibility resource, we were particularly interested in inviting participation from adults and the elderly.

The used scenario in which the experience was developed consisted of an information panel with a description of the experience to be done and the technical equipment for sampling: support table, 23 inch television screen with web cam, laptop loaded with the models, the six marks printed in matte finish surface with the elements to be visualised representing the models. It is worth noting that, given the characteristics of this protected heritage site, one of the requirements was include the minimum number of objects in order not to interfere with the global view of the monument.

The fact that users see their own hands on the screen means they immediately experience and interpret what has to be done while they direct the panel to the camera. The speed at which users learn to handle the marks and remember and find positions and the shapes they want obeys the concept of “proprioception” [13] and can be observed in these immersion experiments.

Another positive aspect worth mentioning [14] is that despite having visited the building or just passing through, visitors were willing to try out different models and dedicate more or less time to each one as they chose. They never said they were tired of standing up or of having to get up and direct the panels towards the video camera. Although the effect of surprise disminished over time trying different models, it persisted and increased at multiple occasions depending on the 3Dmodel.

Figure 5. Some visitors like the elderly showed a lot of interest and surprise when using the application, observing elements that are difficult to see because of where they are (a). The opportunity to locate different elements in the place and identify them in the real space is one of the greatest attractions for users and a game for young children (b).

After the visit to the monument, users were asked to fill a survey in an informal pilot study in order to gather qualitative data. These interviews were conducted individually when they had used the marks and the AR application as they wished. Participants were asked about the degree of satisfaction with the use of this technology and how AR helped them to perceive aspects of the monument, which otherwise they had gone unnoticed. A general overview of the results suggests that users are satisfied with the use of technology, finding easy and useful for enhancing the comprehension/perception of the monument.

Finally it is worth noting that they showed less interest in this conventional participation instrument than in their prior experience with the application. In general, we found that almost all participants felt comfortable using the system, it made an impact on them and they valued the use of AR in real contexts like this one very positively.

## IV. Conclusion and Future Work

This experience with Augmented Reality at this heritage site shows the effectiveness of the tool as an instrument for accessibility and communication of the specific cultural content of the place by actively supplementing and extending vision. Visitors' experience with this technology has provided a profile of component characteristics for adaptation to the target public from the perspective of inclusive design.

The marks were found to be effective and appreciation, impact and interest was found to be linked to their aesthetic and figurative dimension. Users enjoy identifying and selecting the motifs they are going to visualise with this technological tool. They can select what they wish to "enlarge" from the whole visit. This aesthetic and figurative quality increases cognitive compatibility in relation to these signals and consequently, is a determining factor for improving interaction with the system.

The use of this technology acts in certain publics with a “picklock” effect for certain segments [12] who are directly attracted by these communication systems such as children and young people who feel enveloped, comfortable and participative with this type of digital media. Children and young people were eager and skilled in using the marks and tried to explore each model in great detail as if it were a game. However, other visitors closer to the target population of the experience as accessibility resource took part and were very attracted by the idea of being able to visualise the details of the place better. For these users, the fact that the system was easy to use and did not require the use of common computer peripherals was, as they noted, an advantage of the system

The nature of these visual applications closely related to holistic perceptual phenomena makes it difficult to obtain quantitative results [8]. As perceptual phenomena are subject to interpretation, analysis and observation is complex. There has been no attempt to extract quantitative results from the experiment through the satisfaction questionnaire because, although it is a suitable strategy for obtaining information on aspects of technology use and acceptance, it has only been analysed in order to rectify the data collection instrument itself, sound out types of users, their receptiveness, satisfaction, etc.

As a pilot experiment, it has enabled us to profile particular aspects in order to improve the application and its implementation in the Lonja Silk Exchange, such as redefining certain characteristics of the models, their visualization on screen and their evocation from the corresponding mark.

The user's position in front of the screen had to be determined and highlighted and the camera re-located to obtain a medium shot of users during their experience to make it more global and inclusive. Groups of 3D models were established according to proximity in order to favour their localization in the place and details in the satisfaction questionnaire were reconsidered to make it shorter and more operational in this use context.

We conclude that this AR application project will enhance this artistic and historical heritage site in Valencia, giving an interactive resource which increases visitor interest, its participation and a holistic experience of this site.

The future works of the research team are directed to improve the aspects of usability of the tool, allowing thus a better access to the heritage to the groups with limitations in his visual or perceptive capacities.

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