

Smart Architectural and Urban Heritage: An Applied Reflection

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Abstract: The aim of this paper is to present the use of 3D models and augmented reality (AR) to study and communicate architectural and urban values and, therefore, favor the development of dedicated forms of “smart heritage”. The study rises from a reflection on the concept of “heritage”, as defined in the international documents, intended as an evolving idea that puts together tangible and intangible aspects. Moreover, digital technologies favor “phygital” applications where the digital dimension support the traditional ones. In this way, AR allows the superimposition of multimedia information to heritage, respecting the historical matter of the artefacts, and supporting a “smart heritage” application. In particular, mobile AR, with real-time and ubiquitous visualizations, offers the opportunity to show past urban and architectural configurations to investigate and describe the transformations that have led to the current configuration, and consequently highlighting the present historical and architectural values of the buildings. Two case studies are presented: the square of St. Basilio Monastery, with its historical transformations, and the Basilica of Collemaggio, a pivotal building in the rites of “Perdonanza Celestiniana”.

Keywords: architectural and urban heritage; 3D modeling; digital heritage; augmented reality



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1. Introduction

The concept of “heritage” has developed over time; on the one hand, making the difference between tangible and intangible more and more blurred, on the other, by highlighting the importance of the active role of people [1–4].

In this context, the digital technologies have become increasingly important, first of all because they are an integral part of everyday life, and second, because they offer new ways of viewing information: in particular, the different forms of mixed reality [5] allow the superimposition of information of different nature on architectural heritage without interfering with its materiality, i.e., by acting only in the dimension of the visual [6]. This application to cultural heritage can favor the development of new forms of smart heritage.

In particular, in 1999, virtual heritage was defined as “the utilization of technology for interpretation, conservation and preservation of Natural, Cultural and World Heritage” [7]. Unlike this definition, Digital Heritage, as described in its Charter [8], has a tendency to assume an independent connotation and value from the “real” dimension, but the digital objects begin to have a new meaning of “real”. Nevertheless, in digital heritage from real content, conceptually, this digital sphere has to be related with the physical content from which it derives: “in this kind of digital heritage, there is not visualization without a prior reality and, in a philological study of a digital model, we cannot forget its real reference from whom it is born. Therefore, the issues related to data and information grow to include the relationship with history and materiality” [9]. The concepts of “virtual heritage” and of “digital heritage” are well known and discussed by scholars from different fields [10]. Currently, digital heritage involves not only the intangible sphere, but also the tangible one, according to the lines of the so-called “phygital” heritage [11]. In this way, augmented reality or extended reality could be intended as methodologies for advanced information visualization, and therefore useful tools for advanced ways of communication.

Starting from these concepts, the paper presents a reflection on the concept of “smart heritage” as distinct research discourse, i.e., a theoretical approach that finds in the use of digital technologies a necessary condition, but rises from new opportunities for heritage interpretation and presentation [12,13], where people and artifacts interact, in particular through smart devices. According to this context, the concepts of historical, cultural, and aesthetic values take on a central role, and ICT allows the rise of an “ecosystem” where people play a central role in defining these values.

To apply the idea of “smart heritage” to architectural and urban heritage, it is necessary to root the discourse in their own tangible and intangible characteristics—different from other kinds of cultural heritage and built heritage, such as archeological heritage—. Therefore, this paper is organized according to the following parts: the presentation of the general project from which this specific research line arises; an analysis of the specific characteristics and values of architectural and urban heritage that have to be interpreted and presented; a study on how to present these values, in particular through visualization of past configurations; two case studies, where a paragraph verbally describes urban and architectural transformations during the time of a square and of a building, to point out the potentialities offered by onsite visualizations, to favor smart heritage cultural experience.

2. The INCIPICT Project of L’Aquila University

The paper presents the activities of the “Innovating City Planning through Information and Communication Technologies” (INCIPICT) + 5G interdisciplinary project of the University of L’Aquila (<http://incipict.univaq.it/>, accessed on 25 August 2021) related to cultural heritage valorization [14]. The project has the general aim of developing useful studies for the realization of a smart city in L’Aquila, after the 2009 earthquake, and since 2017 it has included research on 5G. In particular, the part of the project focused on cultural heritage is based on the development of mobile augmented reality applications dedicated to the architectural heritage and spaces of the historic city (Figure 1). The activities aim at documenting the profound processes of change in a historical center hit hard by an earthquake, and to encourage the understanding of the values of the places and the reconstruction of their meaning through the onsite storytelling of their history: the ICT are designed to allow, moving freely in the historical center, to superimpose multimedia information and 3D reconstructions of past configurations on the images framed by smart devices, without QR codes or printed targets [15] (Figure 2).



Figure 1. Virtual reconstruction of the St. Basilio square in the seventeenth century.



Figure 2. Virtual reconstruction of the St. Salvatore Hospital in the twentieth century.

ICT colleagues designed the Mobile AR. The authors of the paper—who are scholars of architectural and urban heritage—have studied how to use Mobile AR to develop smart heritage applications dedicated to architectural and urban heritage. Consequently, the research unit of architectural heritage has identified some case studies, realized the historical research, the architectural 3D surveying, defined the interpretation and presentation strategies, and realized 3D scientific models of past urban and architectural configurations. In conclusion, people aged around 20 were asked to experience the app and then respond via a form with questions, in order to evaluate the effects of the views. The form was organized in three parts: the first, with general questions relating to the background of users on the subject of digital heritage and their experiences in this field; the second, with questions related to the specific experience of AR and VR; the third, with specific questions on the contents of the visualizations, to understand the degree of effectiveness of the visualizations in telling the history of heritage in relation to the level of attention of users and their cultural preparation; finally, there were some concluding questions. It is observed that in the face of not-high explicit awareness of technical aspects, but a greater experience in social media attendance, a habit of frequenting digital environments is evident. Mixed-reality views have aroused particular interest. The control questions relating to the contents demonstrate the validity of the methodology for the enhancement of architectural heritage. It is planned, in the future, to enrich the visualizations with multimedia contents, and to include people of different ages and cultural backgrounds, to repeat the test before and after dedicated presentation seminars [16].

3. Architectural and Urban Heritage

Regarding the concept of “heritage”, defining the concept of “place”, The Burra Charter links tangible and intangible values: “Place means a geographically defined area. It may include elements, objects, spaces and views. Place may have tangible and intangible dimensions” [17] (p. 2). Moreover, defining the expression of “Cultural significance”, the Charter states that it “means aesthetic, historic, scientific, social or spiritual value for past, present or future generations. Cultural significance is embodied in the place itself, its fabric, setting, use, associations, meanings, records, related places and related objects” (p. 2). Moreover, a place “may have a range of values for different individuals or groups” (p. 2). The responsibility of people is very important.

The World Heritage Cultural Landscape states “The intangible cultural heritage is traditional and living at the same time. It is constantly recreated and mainly transmitted orally. It is difficult to use the term authenticity in relation to intangible cultural heritage; Some experts advise against its use in relation to living heritage” [18].

At the same time, digital heritage has become pivotal. It marries not only the intangible sphere, but also the tangible one, according to the lines of the so-called “phygital” heritage.

An obvious example is offered by the inscription in 2019 of the so-called “Perdonanza Celestiniana” in the UNESCO Intangible Heritage List. These rites and celebrations have been handed down uninterrupted since 1294 and provide a sense of continuity and cultural identity to the entire community and territory of the city of L’Aquila (Italy) [19].

These traditions cannot be separated from the physical and environmental context, and they find full expression in a procession that crosses the streets of the city and in rituals that take place in the Basilica of Santa Maria di Collemaggio. Here, and only here, in this church—which also houses the tomb of Pope Celestine V, who instituted the rite—do the rites have their fulfillment. It is clear that the dimensions of the tangible and intangible cannot be separated.

Focusing on architectural and urban heritage, the relationship between environment, territory, and buildings is unavoidable. In addition, the concept of landscape has changed over time, with the anthropic aspect that has acquired an ever more important role. The “European Landscape Convention” (2000) states: “‘Landscape’ means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factor” (Art. 1) [20]. The tangible idea of “an area” and the intangible cultural concept “as perceived by people” are related.

In the same way, UNESCO defines Cultural Heritage as “the legacy of physical artifacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations”. Thus, it ratifies the inescapable importance and interconnection of the tangible and intangible characteristics of cultural heritage.

The UNESCO “Recommendation on the Historic Urban Landscape” (2011) states: “The historic urban landscape is the urban area understood as the result of a historic layering of cultural and natural values and attributes, extending beyond the notion of “historic center” or “ensemble” to include the broader urban context and its geographical setting. This wider context includes notably the site’s topography, geomorphology, hydrology and natural features, its built environment, both historic and contemporary, its infrastructures above and below ground, its open spaces and gardens, its land use patterns and spatial organization, perceptions and visual relationships, as well as all other elements of the urban structure. It also includes social and cultural practices and values, economic processes and the intangible dimensions of heritage as related to diversity and identity” [21].

In conclusion, it appears clear that the study, and the telling, of history play an essential role. In this regard, to highlight the difference between the historical disciplines and the “history of architecture”, Gianfranco Spagnesi wrote: “If making ‘history’ always equates to knowing, the History of architecture can only be the knowledge of the physical space built by man, that is of current reality. Therefore, if we want to pose the problem of ‘knowing’ the current ‘reality’, we can only analyze the occurrence of the essential reasons that produced it in a temporal succession” [22] (p. 7), and he adds: “Knowledge of current reality is achieved through the recognition of some significant moments that produced it” (p. 8). Hence the choice underlying the experimentation proposed in this essay: the use of AR to visualize the configurations that buildings and urban spaces had in the past; not for an apology of what is no longer, but to understand and describe the transformations that led to the current configuration, and consequently highlight the present historical and architectural values of the artifacts.

4. Visualization Strategy for Architectural Heritage

In the field of architectural heritage, the generation of images rises from the visualization of complex systems of information, many of which are spatial ones (3D models).

With the diffusion of 3D digital modeling technologies, first, archaeology experimented with virtuality for the displaying of findings and the reconstruction of configurations no longer existing [23], and, consequently, reflections on the potential offered by

computer-based visualizations have been developed [24]. In fact, “The London Charter” and the “Principles of Seville” were developed in the field of archaeology. The first, of general and interdisciplinary value, “seeks to establish principles for the use of computer-based visualization methods and outcomes in the research and communication of cultural heritage in order to: Provide a benchmark having wide-spread recognition among stakeholders; Promote intellectual and technical rigor in digital heritage visualization; Ensure that computer-based visualization processes and outcomes can be properly understood and evaluated by users; Enable computer-based visualization authoritatively to contribute to the study, interpretation and management of cultural heritage assets; Ensure access and sustainability strategies are determined and applied; Offer a robust foundation upon which communities of practice can build detailed London Charter Implementation Guidelines” [25] (p. 4).

According to the principle of “implementation”, the “Principles of Seville” propose guidelines for archaeology. Of particular importance is the concept of “transparency”: “All computer-based visualization must be essentially transparent, i.e., testable by other researchers or professionals, since the validity, and therefore the scope, of the conclusions produced by such visualization will depend largely on the ability of others to confirm or refute the results obtained” [26] (p. 8). In this way, the “paradata” is intended as a sort of “scholia”, that is, an annotation or gloss that accompanies the modeling and visualization procedures to make explicit the scholar’s critical choices [27].

Over the years, the theme of digital heritage has taken on increasingly important implications [28–31].

The architectural heritage model is rooted in the architectural survey: it is a process of historical–critical knowledge that results in the creation of interpretative models that are representative of the characteristics and historical and architectural values of the built artifact [32].

There are numerous differences between the archaeological field and the architectural one: in terms of methodological approaches, specific interests, representation strategies, characteristics of the represented heritage, and last, but not least, the documentary sources, from which important consequences are derived for the more-or-less critical level of interpretation. Furthermore, the fields of application and interest could be different: past configurations of buildings or historic cities that have been heavily modified, architectures that no longer exist, or only designed buildings. The temporal spectrum also varies from antiquity to modern and contemporary architecture. In particular, the availability of archival, project, or even construction site documents with texts, but above all, graphics (such as historical drawings of relief or project, maps, landscape drawings, and also photographic images), offer important references that require an approach that refers to the realm of the drawing and therefore of the visual. In any case, these documents require a historical–critical study. Focusing on 3D modeling, when referred to existing buildings, the restitution is based on a reverse modeling and critical interpretative semantization process, usually integrated by documental and interdisciplinary information [33].

When there are drawings that provide a graphic description of buildings that are only designed or are no longer existing, or of past configurations, the first step consists of the historical study, the redrawing, and graphic analysis of the sources. Then, the passage from discrete two-dimensional representations (plans, elevations, sections of the traditional archival documents) to the three-dimensional continuum of the 3D model multiplies the degrees of indeterminacy. In any case, the scholar/modeler must always keep in mind whether his/her work is aimed at the study of the architectural heritage or at a communication addressed to nonexperts in the sector [34]. Dynamic, interactive, and ubiquitous visualizations in virtual reality, augmented reality, and mixed reality are now common practice. In particular, these offer important tools for the study and narration of the values of architectural and urban heritage [35]. The measurement phase of scanning is essential, but it is only a first necessary step [36]. In the same way, the type of 3D model (CSG, MESH, NURBS, H-BIM) used to represent heritage is a critical choice [37].

5. Two Case Studies

Two case studies follow, developed in recent years as part of the INCIPICT project, both relating to the city of L'Aquila. The first concerns an urban area: the one today characterized by the former Hospital of St. Salvatore and the Monastery and St. Basilio square [38]. The second relates to the Basilica of Collemaggio, a pivotal building in the rites of "Perdonanza Celestiniana", recognized as an intangible heritage by UNESCO in 2019 [39].

Focusing on St. Basilio Square, the study is founded on the historical–critical method, and the virtual reconstruction of the transformations that affected the urban landscape, combining the survey of the current configuration with the archival research. The available documentary apparatus, different in relation to eras, includes historical maps, textual and graphic sources, and vintage photographs.

Until the twentieth century, the area of the former St. Salvatore Hospital was characterized by St. Basilio and St. Agnese monasteries, outlining a large open space. The site was connected to the historical center by paths coming from Via Cascina (urban foundational axis) and Via Paganica. After the earthquake of 1703, the architectural configurations of St. Basilio and St. Agnese were renewed, while the little church of St. Pietro e Nicolò della Genca was demolished. Afterwards, the consequences of Napoleonic laws and of new uses of the unitary Italian Kingdom modified the buildings.

In the twentieth century, the enlargements of the built fabric affected the crown of gardens and green areas internal to the urban walls. In particular, the realization of the Duca degli Abruzzi boulevard (1933) was related to a design of an overall expansion and renewal of the urban system that led to the building of the Hospital of St. Salvatore and of the educational facilities along the street. The avenue moves according to its own level, not related to the natural ground, and therefore it interrupts the historical streets. St. Salvatore Hospital was renewed and expanded in 1931–1934 with the inclusion of St. Agnese Church and the demolition of its Monastery and of the neighboring Church of St. Maria del Guasto (XV century), whose façade was rebuilt in 1935 as elevation of St. Maria degli Angeli Church. Moreover, the Dispensario Antitubercolare (1935) and the Dispensario di Igiene (1939) were built. The overall perception of the complex modified, today it is set according to the axial views of Nizza Avenue toward the Hospital, and of Natali Square with St. Basilio. Digital models favor the visualization of spatial views now no more attemptable, and therefore the understanding of architectural and historical values: the views by the historical paths of Via Cascina (16th and 19th century) (Figure 3), and Via Paganica (16th and 19th century), and the open space between the monasteries then reduced by the building of the Dispensario di Igiene that no longer allows the perspective view of St. Basilio Monastery (16th and 19th century); the visualization of no longer existing, or modified, buildings, such as the former Hospital in its configurations (16th, 18th, and 19th century).

The second case study concerns the Basilica of Collemaggio and its old Baroque apparatus (Figure 4). Currently, the church has a substantially medieval configuration, up to the transept. This is the result of a stylistic restoration carried out in the early 1970s, in which the Baroque configuration was removed, aiming at restoring the church to a supposed medieval appearance. Based on the digital survey of the current church, a 3D model of the no-longer existing Baroque structure of the main nave is created, according to the studying of the graphic and photographic documentation of the period. The aim is its visualization and evaluation for the telling of the history of the Basilica, through an augmented reality application, which makes it possible to display, dynamically, and in real time, information related to what has been framed by a mobile device (Figure 5).



Figure 3. Augmented reality application for the visualization of past configurations: view of the St. Basilio area coming from the historical paths of Via Cascina (16th and 19th century).

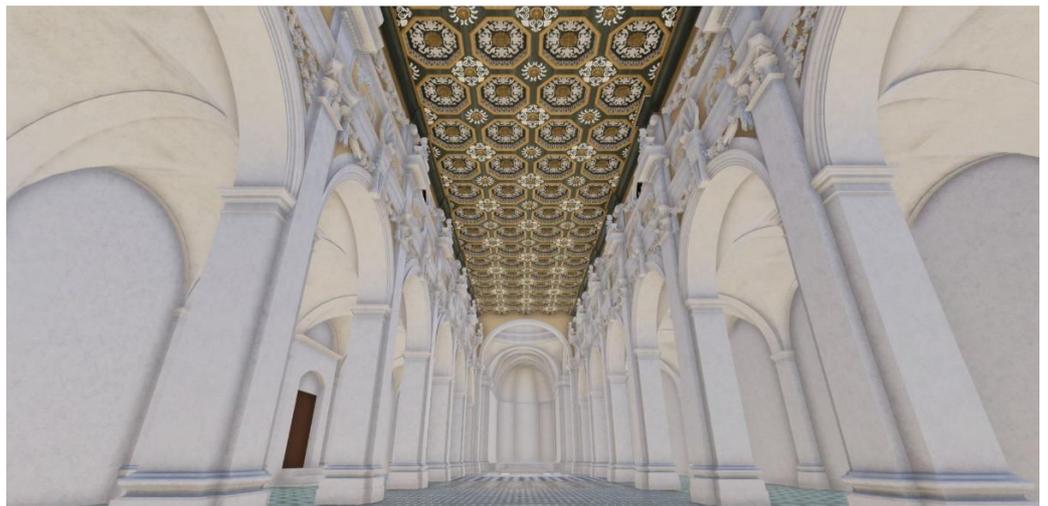


Figure 4. Virtual reconstruction of the no-longer existing Baroque structure of the Basilica of Collemaggio.

Future research lines will concern the evaluation of these views by users, with the involvement of people of different ages and cultures, asking them to answer questionnaires to evaluate the effectiveness of this method in telling the history through augmented reality applications.



Figure 5. Collemaggio AR app for viewing the Baroque configuration: virtual reconstruction of the Baroque structure, and superimposition with the current Basilica.

6. Conclusions

The traditional approach to the smart city, focused on infrastructural networks, is developing in the sense of a cultural dimension, where the concept of “smart cities” is turning into the one of “smart places”. Operationally, the “smartness” requires the integration of “objects” with sensors for their enrichment with information, so that they can interact with the environment and with the people. In particular, mixed-reality applications allow you to add multimedia information to buildings and the environment surrounding the user. In this way, it is possible to favor the development of an advanced system in total respect of the historical “matter” of the works of art, where the interaction between technological applications and the physicality of the heritage occurs only in the dimension of the digital image, without inserting technological prostheses in buildings or cultural heritage.

This kind of experimentation is carried out by the research group of the University of L’Aquila for the enhancement of the cultural, architectural, and urban heritage of L’Aquila. The application, which can be used in urban areas of the city and in specific interiors, is implemented to tell the history of monuments and places, also by superimposing, in real time, 3D virtual reconstructions of configurations of the past that are no longer in existence. A necessary condition is the creation of 3D scientific models of the past of the buildings, critically constructed in relation to the surveying of the current situation and to historical documentary sources. The overall aim is that of the configuration of a sort of “digital museum” of the historic center, where the city itself is configured as a museum of itself, and the information is freely available by walking through its spaces and visiting the buildings.

The belief is that buildings, which are the result of processes of modification and stratification over time, are the witnesses of the ideas that have led to current configurations and to the present culture. They embody their own tangible values, but they are the mirror of intangible values.

In built heritage fields, and in particular in the architectural and urban ones, their transformations over time can be described by 3D models that need to be realized according to a scientific process of study and modeling. Augmented and mixed-reality visualizations offer the opportunity to show buildings' modifications superimposed on the current views—on smart device screens—that is in relation to the existing artifacts, to highlight their history. The mobile AR gives everyone the opportunity to interact ubiquitously and in real time with architectural artifacts. Moreover mobile AR allows the visualization of information without any physical interaction: for example, without inserting sensors, or even just tables or captions with QR codes, that is without the use of any material system, thus favoring the respect of the matter of the built heritage. The fact that facades or architectural spaces are the target for the direct superimposition of architectural 3D model images supports the interpretation of historical buildings. In this way, ICT can sustain the rise of new processes for smart heritage development, but also of smart interpretation and presentation of heritage.

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