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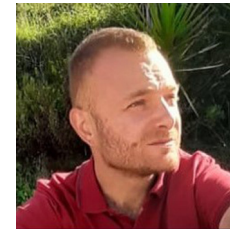
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3D models and digital images for interpreting and communicating the evolution of the historic city

The city of L'Aquila is characterised by a variety of cultural heritage, both monumental assets, such as churches and noble palaces, or minor buildings, such as the many civil houses, which represent the historical evolution and changing material and immaterial cultures over time. This heritage is enriched by the public areas the citizen recognises as their own and in which daily life is conducted in its multiple aspects. Among these, a central role is played by Cathedral square, which represents a public space that synthesises the evolutionary history of the city, incarnating its collective identity values. This place, the scene of multiple events, has undergone numerous transformations. The digitisation and three-dimensional reconstruction work matured as a result of scientific research based on the principles of Heritage Interpretation, which favours the dissemination of scientific knowledge. A digital application has been developed that exploits the communicative potential of Virtual Reality (VR) technologies to make the different settings of main square between past and present accessible in immersive and desktop mode, thus enabling the main architectural transformations that have taken place over time to be visualized. App based on VR technology are capable of narrating a broad audience about the architectural evolution and environments over time, facilitating the production of images that recount moments from the past, thus helping to promote the city's tangible and intangible heritage.

BUILT HERITAGE AND URBAN SPACES: SHARED PLACES AND COLLECTIVE MEMORY

Normally, cities are rich in diverse cultural heritage, ranging from artworks gathered in museum collections or in churches to the monumental architecture that set the scene for city life with palaces, churches, fountains and parks. This cultural heritage, which is the results of local artistic expressions and intertwining of craftsmen and cultures, is essential in the collective memory of the local communities that can recognise themselves in it. For this reason, one of the main objectives of those dealing with cultural heritage, in a broad sense, is to encourage heritage understanding by disseminating and promoting the research results to a broad audience of citizens to increase actions of protection and preservation through attribution of value. To achieve this goal, it is essential to work taking into account disciplines such as Heritage Interpretation and Public History for the definition of workflows and for the realisation of products and tools capable of reaching the most heterogeneous variety of users, both culturally and socially point of view. This aspect is linked to the communication and dissemination of the tangible and intangible values of heritage that contribute to defining what is known as the Heritage Community and to triggering virtuous processes and good practices with positive repercussions on the preservation and transmission of cultural heritage in all its facets. The need to document, communicate and disseminate heritage values is even more pronounced for territories in our country are exposed to natural hazards of various kinds, where cultural heritage, both tangible and intangible, is constantly under threat. One significant example is the city of L'Aquila, which has often been subject to catastrophic events, which have been followed by many reconstruction activities (Galadini & Varagnoli, 2016; Fiorani, 2011). A great weight in the collective memory of the citizens of L'Aquila, especially in the latest generations, has been taken the recent earthquake (fig. 1) in addition to distorting the perception of certain urban portions, still under reconstruction, has often made it

Fig. 1 - Photos of the city with the monuments damaged by the earthquake and the reconstruction cranes.

difficult to enjoy the collective heritage. This difficulty has highlighted the importance of tangible and intangible cultural heritage in the citizens' daily lives, as it helps generate a sense of belonging and strengthen collective identity.

A particular value within the historical urban context has been reserved for public spaces such as squares, which have always been identified as meeting places, and deputed to perform political, commercial and religious functions; the overlapping of these multiple aspects has consequently conditioned their structural conformation (Piccinato, 1935). The intertwining of politics, art, commerce and community life made these places the major expression of the city's identity, becoming the overlapping space of individual and collective memory resulting from living private life in public (Barbiani, 1992). Among the many squares in the city of L'Aquila, 'Piazza Duomo' is extremely interesting because it synthesises the many material and immaterial values resulting from the numerous events that have contributed to changing its appearance over the centuries (Fig. 2).

Documenting the aspects that characterise the tangible and intangible cultural heritage, and identifying the best strategy to tell them to the public and citizens, are the main challenges of the research that our research group is addressing starting with the digitisation of the city. The analysis process has been approached in a multidisciplinary way, using multiple sources ranging from archaeology of the architecture to iconographic sources. Therefore, starting from an initial experiment carried out on a portion of the square (Savini, Cordisco & Trizio, 2023), the focus of the work is to achieve the objective of representing the appearance that this area of the city had in the past through the virtual reconstruction of some buildings. The historical buildings that frame the square are, in fact, closely connected to the religious, political and social expressions that influenced the transformation of the square itself. To achieve this goal have been adopted analysis processes based on Heritage Interpretation and visual communication in the digital environment, identifying historical iconography as the starting point to make the spectator travel through time by

Fig. 2 - Map and photos of the main square of the city of L'Aquila.

projecting him, thanks to immersive Virtual Reality (VR), into a historical setting of the urban context.

DIGITAL TECHNOLOGIES TO SUPPORT HERITAGE INTERPRETATION AND COMMUNICATION

The main objective of the research carried out in this paper was to identify the most appropriate digital tools for learning about the history and intrinsic tangible and intangible values of heritage, equally capable of strengthening the collective cultural identity in L'Aquila city, especially of the new generations (Rahmani et al., 2022), who have suffered a kind of dispersion regarding their cultural heritage, largely due to the earthquake. In fact, due to the long process of reconstruction still in progress, large portions of the urban fabric are not usable and have never been available to the generations born after the earthquake, for whom it might be of help to start from elements with a strong symbolic meaning, such as the main square, in order to regain possession of the concept of cultural identity. In cases such as these, it is possible to speak of "interrupted landscapes" to refer to the interruption of the individual stories that bind people to their territory, and which generates an alteration of the natural and continuous process through which people attribute a value to their habitat (Clemente & Salvati, 2017). Through the new technologies, we intend to bridge the gap related to poor consideration of the social dimension of urban landscapes and the built environment in reconstruction processes. Indeed, the concept of 'collective identity' is closely connected to attachment to place and, by extension, to cultural heritage.

The challenge taken up by this study was precisely to identify tools and languages capable of fostering young people's attachment to the historic city through a narrative by images generated from digital processes, based on the principles of Heritage Interpretation, discipline that is recognised as having an important role that goes beyond that of fostering cultural tourism (Hodges, 2019). Furthermore, based on the assumption that images are a powerful tool for expressing a community's

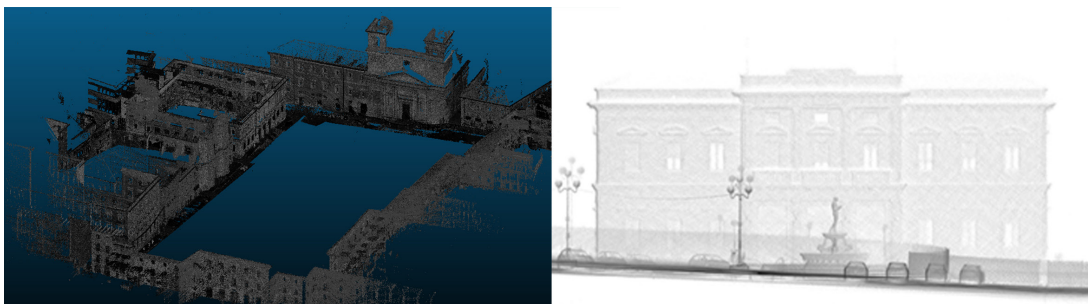Fig. 3 - Photos of the old "Cancelle" shops in the actual site, in Simeonibus Street.

Fig. 4 - Output of the mobile laser scanner survey. On the left, point cloud and on the right view of a façade.

Fig. 5 - Output of the photogrammetric survey of "Poste e Telegrafi" palace (top) and "Cancelle" (bottom). On the left mesh in solid view, on the right model textured.

cultural identity (Ruiz-Ruiz et al., 2022), it has been made to use digital technology to generate images aimed at analysing the historical evolution of an urban place and to strengthen the feeling of belonging, especially in younger people, and thus transform citizens into the bearers of their own cultural heritage. In this sense, the interpretation phase was based on scientific information, on an in-depth multidisciplinary study that took into account the characteristics and evolution of the site and its context (Brunelli, 2014). Furthermore, the interpretation, in line with the indications contained within the Ename's Chart (Ename's Chart, 2008), involved a detailed and systematic analysis of architectural and historical data, such as written, iconographic and photographic sources, which allowed the proposed reconstructions to be hypothesised. Aware of the effectiveness of three-dimensional reconstruction for the representation of architectures that no longer exist in the city (De Gasperis, Mantini & Cordisco, 2018; Trizio et al. 2019; Maiezza, 2020; Brusaporci et al., 2021), the potential of digital storytelling, understood as a variety of digital multimedia platforms designed for narrative purposes, was explored to foster the digital narration of urban heritage, taking into account the importance of production quality for a high level of user immersion (De Paolis et al., 2023).

THE TRANSFORMATION OF PIAZZA DUOMO TOLD DIGITALLY: A JOURNEY THROUGH TIME IN VR

L'Aquila has several public spaces in which diverse events take place. Among these, squares play a key role, and their large number can be ascribed to the founding process of the city's foundation itself. Without going into the historiographical complexity of this process, it should be emphasised that the desire to build the settlement in its present location led to the city's foundation during the 13th century. This process was favoured by the inhabitants of the surrounding castles area who settled within the city space (Redi, 2008). Each community that contributed to the foundation built a church, a square and private dwellings (Clementi & Piroddi, 1986). This settlement system particularly influenced the final

Fig. 6 - Digital repositioning of the old "Cancelle" in their original position and simultaneous visualization with the current "Poste e Telegrafi" palace.

urban layout of the city, defined by small and large spaces enclosed within the streets of the centre, which are still legible today despite the modifications undergone over the centuries due to repeated seismic events. To the squares have therefore been attributed, since their medieval foundation, a symbolic value that makes them strong identity spaces (Centofanti et al., 1992) and the one that most embodies these values is 'Piazza Duomo'. The city's main square, also known as the market square because of the activity that was regularly carried out there until the 2009 earthquake, has always been in constant evolution and in close relation to the political, religious and social choices that have influenced the surrounding architecture and that continue to nowadays to modify its appearance in order to adapt it to modernity. Material sources, i.e. the buildings with traces imprinted on the masonry, and documentary sources tell us about a space that has changed over time, which today presents

itself with a series of commercial buildings and two religious buildings. The square, which overlooked in the Middle Ages only the Cathedral, underwent a significant change during the 18th century with the construction, on the south front, of the Church of 'Santa Maria del Suffragio', known in the city as the 'Anime Sante' Church. The evolution of the cathedral façade, dedicated to Saints 'Massimo' and 'Giorgio', also contributed to changing the appearance of the square. In fact, the mediaeval features of the classic façade with horizontal crowning, of which one of iconographic evidence can be recognised in the famous painting *The Preaching of St. John of Capestrano* preserved in the National Museum of Abruzzo (MuNDA), gave way to the Baroque guise with bell towers testifying to the last building phase of reconstruction following the 1915 earthquake.

A further transformation of the square took place in the early 20th century when, in the south-east-

ern corner, at the junction of Arcivescovado street and close to the 'Anime Sante' church, the imposing 'Poste e Telegrafi' building was constructed (Maiezza, 2020) replacing the last medieval shops that overlooked the square, known as 'Cancelle'. These no longer functioned as fish shops and were reduced to poorly preserved warehouses (D'Antonio, 2021). Despite this, due to their recognised historical and artistic value, these shops were not demolished but dismantled and relocated in the immediate vicinity of the square. The characteristic shops made of squared stone masonry with an elegant string-course cornice and the characteristic openings for the display of goods are still recognisable today in Simeonibus street, although completely decontextualised (fig. 3). Therefore, a Virtual Reality app that allows an interactive visit to the actual square and visualises, instead of the 'Poste e Telegrafi' building, the small medieval shops in their original location was created. The

knowledge phase was implemented with the digitisation of the real context, through multi-sensor and multi-scalar acquisitions, from the general to the particular. The current square, with buildings under reconstruction and the modernisation sites, was digitised through an instrumental survey using a mobile laser scanner based on SLAM technology, specifically a Zeb Horizon. Two scans were carried out which, once fitted together, returned a point cloud of approximately 75 million points. This, after being post-processed and decimated, was used to obtain the plane-volumetric restitution aimed at the geometric definition of the square and the facades of the buildings facing it (fig. 4).

With regard the change of scale from general to detail, the terrestrial photogrammetry was adopted for the digitisation of single artefacts, and specifically the 'Cancelle' and the 'Poste e Telegrafi' buildings were digitised. The instrumental survey using a Nikon Z 50 camera mounted on a telescopic carbon-fibre pole was carried out, which made it possible to obtain high-resolution textured models from point clouds with greater precision (Fig. 5). The survey outputs were appropriately postprocessed and integrated with each other to be used as an integral part of the virtual scene in the digital VR application that narrates the temporal evolution of the square. The digital project was realised by integrating different modelling software, render and game engine platforms. The point clouds, both of the general and detailed context, were filtered and decimated with Cloud Compare software. These, exported in *las format, were imported into the Twinmotion software, which allowed the overlapping in the virtual space of the two buildings. In this way, it is possible to visualise the square in its current aspect with the 'Poste e Telegrafi' building next to the 'Santa Maria del Suffragio' church and, at the same time, thanks to an overlay, the 'Cancelle' in their original position (fig. 6). The mesh models of the buildings under investigation were edited through optimisation and simplification procedures in the modelling Blender software and implemented with step-by-step solid modelling (fig. 7).

These models were also imported into the Twinmotion software, which made it possible to enrich the different scenes with urban furnishings and characters from the various historical periods created on the basis of an interpretation process of historical iconographic sources (fig. 8).

The navigation of the scenes is made possible by the Unity game engine platform used for the realisation of an immersive and interactive digital app. By means of buttons and hotspots, it is possible to view the square in its current and historical aspects, accessing informative data structured in an appropriate graphic and visual language.

The research results were, therefore, processed into an application capable of narrating, through 360° images, the evolution of the square, communicating its transformation over time in a popularised manner. The application makes it possible to navigate the virtual space in the first person and, by means of buttons, travel through time to view settings from the past and thus admire the square with the Cathedral in its medieval aspect (fig. 9) or with the 'Cancelle' in their original place in a scene set in the early 1900s (fig. 10).

The digital product, thanks the design of an interactive virtual environment capable of engaging the viewer, can be used both in desktop mode and by high-performance devices such as the Oculus Quest 2. The visitor can interact with the virtual space and, in addition to freely exploring the square, can access additional multimedia content such as detailed photos, texts and 3D models accessible via external links. Through a link, it is also possible to access the numerous historical images on social media published by individual citizens (Tata, 2023). These pages are important because, besides representing a participatory form of the knowledge creation process, they contribute to the preservation of the historical memory of places in the same way as authentic archives. The expedient of connecting a product resulting from the research with the thematic page on 'Piazza Duomo' of the community "*L'Aquila de 'na 'ote*" (fig. 11) aims to strengthen the link with the citizenship, contributing to the definition of the Heritage Community and implementing the participatory co-creation of knowledge about cultural heritage and the preservation of historical memory.

Fig. 7 - Images of the three-dimensional modelling phase: at the top the solid model, in the middle the definition of the architectural elements and at the bottom the rendered model.

Fig. 8 - Screenshot of the Twinmotion software during the implementation phase of the scene with street furniture.

FUTURE ACTIONS AND STRATEGIES FOR THE DEVELOPMENT OF HERITAGE COMMUNITIES

The work presented here is part of a larger project that the working group is carrying out for the city of L'Aquila digitisation. The focus of the project is to identify the places that characterise the city's cultural identity and then define inclusive communication strategies that are able to increase accessibility in terms of knowledge. The digital project aims to communicate the evolution of the city's main square and to make a wide audience understand, thanks to the communicative capacities of 3D models, the continuous evolution of the city and the majesty of certain projects aimed at modernising the appearance of the square over time, but also to preserve the historical memory by translating it into images so that it can be transmitted to the youngest citizens. The choice of structuring the digital product with the logic of an educational entertainment product aims to provide tools to help the younger generations, who are used to seeing their city as a huge reconstruction site, understand the value of their city.

In this regard, digital environments are powerful artefacts both for representing the architecture that characterises the current setting of the square and for reconstructing, through a scientific process, its appearance over time. Virtual Reality - in its multiple declinations and thanks to the diversified forms of use ranging from 360° videos to Apps, up to the Metaverse - catapults the spectator into the settings of the past and offers the possibility of interacting with the virtual environment, making the user participate in the learning process. The use of digital communication promotes accessibility to culture by breaking down barriers, not only physical, but also sensorial and cognitive ones. The use of graphic language, capable of dialoguing with a heterogeneous public in terms of age, level of culture, language and more, is the choice that best meets the needs of the project, which aims to expand knowledge and education on the cultural heritage of the city of L'Aquila. Lastly, further implementations are among the project's future prospects, not only with the support of the municipal administration, but involving the entire citizenry, which becomes promoters of its heritage and custodians of collective historical memory in the perspective of the Heritage Community.

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Fig. 9 - Image of a rendered scene of the Cathedral with its medieval-style façade.

Fig. 10 - Image of a rendered scene from the early 1900s with street furniture, characters and objects.

Fig. 11 - Screenshot of the application in operation with the link to the Facebook page L'Aquila de 'na 'ote (https://www.facebook.com/laquiladenaote/?locale=it_IT . Retrieved March 10, 2023)..

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