AR&AI
urban enhancement

Rebuilding Amatrice. Representation, Experience and Digital Artifice

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Abstract

The Diocesan Museum of Amatrice, razed to the ground by the 2016 earthquake, exhibited works of sacred art but also materials on the building, the former church of Sant'Emidio, and on the territory. The grave loss provokes a reflection on the psychological significance of heritage, the lack of which creates disorientation among the population. Technologies help to regenerate the bond with the territory, to search for one's own identity not only in the tangible dimension, which is hardly visible today, but also in the relationship between objects, stories and meanings to be reconstructed. The research proposes a path of re–appropriation that identifies the semantic domains of the community and associates them in the territory through the dissemination of traces: images and stories are the new points of contact georeferenced around the voice of the protagonists. Two multimedia installations emphasize the evocative interaction between reality, memory and reproduction of the intangible to promote the common good of collective memory.

Keywords
cultural heritage, identity, storytelling, living experience, immersive technology.

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Human Intelligence for Sensitive Places

The research project intends to represent part of the lost heritage through an immersive and interactive system aimed at the experiential involvement and dissemination of the contents of the Diocesan Museum of Amatrice with visual storytelling and interactive iconography methods. The museum before its physical reconstruction can be expanded through an installation of the *Digital Living Library*, a solution to make the oral history of the territory alive through the direct testimonies of citizens. According to the Nobel Prize for Economics Amartya Sen, social participation depends on what he defines as capability, that is, the ways that all citizens need to be able to exercise their rights as a practical expression of freedom [Saito 2003]. The research goal is to investigate a new format of experience, supported by new technologies through the application of two fundamental principles: emotional storytelling, which addresses the need of citizens to connect emotionally to places before getting involved in a cultural experience; and the suspension of disbelief, which highlights how people tend to approach this form of interaction mainly for reasons of leisure and socialization, so learning becomes a consequence of involvement without making the didactic purpose explicit. It is a process that supports the development and enhancement of specific but also general "skills" that can allow access to knowledge. The exercise of memory develops a cognitive sense that makes us reflect on the material aspects and the psychological state, in the cyclical "return" to the places that were and in the rediscovery of the very meaning of living. It is important to underline how sharing the different expressions of intangible heritage, as a participatory cultural activity, is central instead of somewhat peripheral in intervention in earthquake–hit territories. Instead of adding a level of subjectivity to tangible forms of heritage – buildings or collections –, these being lost or heavily damaged following seismic events, the multiplicity and diversity of the inhabitants' stories, memories, and experiences become the only possible way to preserve what remains in memory.

Fig. 1. A mobile interactive booth for installed in the civic space of Amatrice.

Moreover, this seems significant when time and money constraints often dictate that the cultural loss resulting from an earthquake is, at best, the last to be healed. If putting the rubble back together is not always possible, the use of technological but human–centered solutions can instead help to put together the experience and widespread knowledge of an entire community. Representing culture and human heritage in the digital age is the contemporary challenge for designers figuring out interiors for community centers, like a museum or a library or the new hybrid spaces designed as urban interiors [Amoruso 2019].

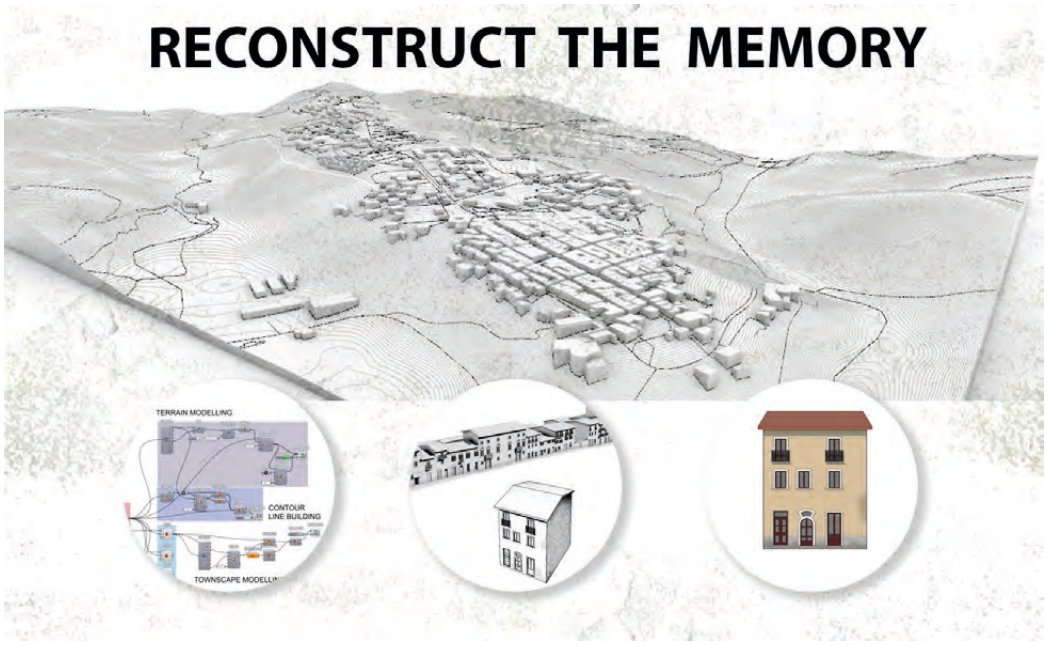

Fig. 2. Algorithmic generative representations for the reconstruction of the Amatrice.

Social Objects and Emotional Storytelling as Design Strategy

Taking inspiration from the 'human library' phenomenon, that is, that a person's personal and daily history can become "culture" for other people. The experiential format for Amatrice is related to culture as a common good produced "from below" in a way. The project starts from the principles of *Design for All* [Stephanidis et al. 1998] and *Audience Development* [Bollo et al. 2017], intended as levers to expand cultural participation. Specifically, a *Design for All* approach ensures the physical and cognitive accessibility of the environments and tools with which visitors interface. This concept has significantly developed in the Human–Computer Interaction (HCI) literature following numerous researches [Stephanidis et al. 1998]. In terms of *Audience Development,* the project aims to reconcile the possibility, for people accustomed to enjoying cultural experiences, to have a 'deep' heritage experience, 'deepening' the so–called 'diversifying.' The project proposes two key concepts: the 'social object,' a concept theorized by sociologist Jyri Engeström in a broader theory called 'object–centered sociality' [Engeström 2005] and adopted in the museum by Nina Simon [Simon 2010]. 'Third entities' create processes of conversation and socialization between people who do not know each other. Recognizing the importance of artifacts, Simon suggests rethinking the objects in a museum's collection as points of contact for conversation, with oneself, the cultural organization and its staff, and the other participants, present and future. It is essential to specify that this process gives technology a strategic role, enabling this 'multilevel conversation', both in synchronous and asynchronous mode. In the field of Audience Development, the research body Morton Smyth had already spoken of the need for cultural organizations to use 'banner products,' or artifacts "that speak loud and clear to novices, suspicious, apathetic to the frightened: this is for the likes of you" [Morton Smyth 2004, p. 33]. Compared to the four categories of social objects identified by Simon, 'Personal,

Active, Provocative, Relational', the storyteller–booth falls within that of 'relational' objects, so defined because they explicitly refer to interpersonal use. As an emblem of a relational social object, Simon indicates the telephone whose use presupposes the presence of an interlocutor 'on the other side', despite its invisibility. The phone connects us, despite the distance. It allows us to listen and, at the same time, allows the exchange of the voice. In short, it places us in a dialogic state of openness to others. The second design principle is 'suspension of disbelief,' introduced by Samuel Taylor Coleridge in 1817. Typical of theatrical performances but increasingly adopted in the exhibition/museum environment (typically through immersive installations). The audience experiences the state of suspension of disbelief through extreme care and coherence of the contextual/scenic elements of the narrated world. Once this state is in the air, the viewer/visitor lives the experience represented as actual. This form of total absorption brings learning to an irrational level: the viewer lives the experience and only consequently finds himself having learned things. This dynamic is also the basis of gamification, which applies the technique of suspending disbelief in making the user act in the role of a character.

Technology–Driven Installations for Memory as Commons

In the case of Amatrice, the triggering of the suspension of disbelief is fundamental. A mobile interactive booth and an immersive space were presented to the Amatrice administration and the World Monument Fund and received positive feedback. Monuments Fund (WMF) is a private non–profit organization founded in New York in 1965, created to preserve historical architectural artifacts and sites of historical and cultural significance worldwide through fieldwork, promotion, and training funds of local experts. The WMF has turned its attention to the Cola Filotesio Museum not only because it represents the cultural wealth of Amatrice but also about the history and identity bond that the population has maintained and maintains with the city and its territory.
Among the social objects outlined by Simon, the project chooses relational ones, that is, which explicitly refer to an interpersonal use. The immersive installation enables suspension of disbelief that is the imaginative condition in which the individual arises to escape reality and 'enter' the fiction. This concept, central to the performing arts, also asserts itself in the exhibition/museum context, typically through immersive installations. In a society of continuous learning, it is essential to translate knowledge into accessibility. Furthermore, possibility between real and virtual nature, physical and digital, through information systems accessible locally: multimedia stations dedicated to the exploration of digital collections, touch walls to form immersive environments placed in the museum rooms to strengthen the communication of the rooms. The installation of an immersive space with three interactive walls of 6 square meters, each with e–REAL technology by Logosnet, is planned according to public communication and civic participation strategy. The user interfaces, with touch modes, but possibly expandable with eye–tracking and gesture systems, stimulate multisensory perceptions through the simulation of participatory scenarios inspired by the territory and the museum's collections. The interactive walls enhance the museum experience by making masterpieces of art accessible engagingly and interactively. The system integrates the visualization of the works with infographics. It allows exploring a cultural microcosm with the touch of hands and the fusion of real and virtual worlds. People are visiting a 3D scenario where they can interact with natural gestures and experience the world from different points of view at the same time. The dynamic contents to be explored in an immersive way are usually developed within a virtual Unity environment, a graphics engine that allows 2.5–3D views without glasses or wearable devices. C #, alternatively Javascript and Python, are the programming languages used to develop the components of the scenarios. A further objective is developing a mobile interactive booth intended to collect direct testimonies from citizens on the heritage of Amatrice, life stories, memories of the city to be georeferenced. The booth allows the recording of vocal contributions, according to a series of topics, issues, and keywords divided into thematic sections: territory, history, places, traditions, people. Inside the mobile interactive booth, among the features provided, there is an interactive electronic whiteboard called e–Wall (writing, drawing, and painting, manipula-

tion of images and virtual objects). The system includes a voice recognition system that allows voice commands for the functioning of the e–REAL system, for example, through the use of "formulas" to make digital objects appear.

Conclusions

Therefore, the research project proposes a new idea of a temporary and experiential museum as a cultural garrison and for the transmission of memory and spatiality that digitally expands into the immaterial dimension of informal accessibility and discovery. Technologies are changing the relationship between users and the environment of use of cultural content in museums, libraries, and learning places. The environments are transformed considering their virtual extension and allowing a range of customization linked to content selection. To these, Manovich also adds the interactive cultural experience, the possibility of enjoying cultural experiences and products by visitors, textual, voice, and visual communication, and participation in a sort of information that regenerates 'ecologically' knowledge and its dissemination. Rebuilding Amatrice is a complex artifice with an uncertain outcome. In respect of the cultural heritage, it finds its form through the values of living and the experience of those places that only its community knows.

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AR+AI = Augmented (Retail + Identity) for Historical Retail Heritage

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Abstract
From the cafés in the dreamlike square in Rimini depicted by Fellini in *Amarcord* to the movie theater in the village of Giancaldo depicted by Tornatore in *Nuovo Cinema Paradiso*, historic shops represent a rich and significant cultural heritage. The protection of historic shops is often the subject of specific dedicated regulations throughout the country, aimed at preserving their compositional identity and preventing the impoverishment of their urban image. In this context, starting from the analysis of future scenarios in the field of retail design, the proposed contribution aims to open new perspectives on the potential offered by the use of AR and AI technologies in the identity enhancement of the architectural heritage of historic shops. The idea, presented through a real case study, is that the concept of Augmented Retail can represent a strategy to achieve an Augmented Identity, changing the retail space from a 'product window' to an 'experiential theatre'.

Keywords
AR–AI, historic shops, retail, heritage, valorisation.

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The Shop as an Identity Value

Historic shops represent a cultural heritage with a strong identity value, and this can be seen in the many artistic and cultural expressions in which the image of Italy is portrayed through that of its historic places: interiors, shop windows, overlooking squares and open spaces, urban views, etc., which give vividness with intense colours to the glittering image of the '*Belpa*ese'. In this regard, the dreamlike narration of the city of Rimini by Federico Fellini in *Amarcord* is emblematic, as is the story of the movie theater proposed by Giuseppe Tornatore in *Nuovo Cinema Paradiso*. The life of the community is marked by the interior and exterior spaces, by the scenery of the square (characterised by the iconographic apparatus of neon signs) and the shops. The identity traits of the shops mark the succession of times and tastes: "it is the shop which best indicates the level of industrial and economic development of a country, and which also best reflects the state of its culture and art" (Sabatou 1938/1984, p. 6, translation by the authors). At the same time, the shop represents the constitutive element of the urban landscape; as Guido Canella affirms, "the 'living pictures' of the shops facing and lined up on the street are breaks of a hoped–for city landscape, where [...] objective, symbolic, unifying, deforming intentions, corresponding to an aesthetic feeling, enter each time" [Canella 1984, p. 2, translation by the authors] The historic shop substantiates the very image of the country, determining its perception from the outside and becoming fully part of the collective memory: "If Italy loses its shops, we lose Italy as we know it" [Petrini 2020, translation by the authors]. In the regulatory background, the *Codice dei Beni Culturali e del Paesaggio* (D.L. n. 42 of 22 January 2004) is not specific about this type of property and generically includes it among the "immovable and movable property of artistic, historical [...] and particularly important interest". The first explicit reference to "historical traditional premises" was made in D.L. 91/2013: it is often the individual regions that enact specific provisions for the protection and enhancement of these assets in the form of regional laws. In recent years there have been many initiatives aimed at raising awareness of the issue and comparing experiences at national level. Many contributions confirm the attention paid by the scientific community to commercial establishments; these are almost always census activities, generally based on the architectural survey and cataloguing of historic shops and aimed at enhancing them in various ways (dedicated tourist circuits, restoration work, protection actions, also in terms of safeguarding their use, etc.).

In this context it is possible to list some significant examples: starting with the cataloguing of Turin's historic shops, begun in 1985 [Tagliasacchi 1985], then systematised [Ronchetta 2001] and extended to the entire Piedmont region [Ronchetta 2008]. The cataloguing work, shared publicly through the *MuseoTorino* portal, makes it possible to consult documentation sheets and digitised materials on the individual businesses recorded, also by locating them on a map. Other examples are represented by the survey and cataloguing of historic shops in Lucca [Pellegrini 2001], aimed at documenting the technical expertise of the artisans and promoting restoration and enhancement actions, the cataloguing of commercial activities in Tuscany [Preite 2007], the census of historic premises in Friuli Venezia Giulia [Regione Autonoma Friuli Venezia Giulia 2010], by the proposal for a *Multimedia Information System* of the commercial activities in Bologna [Bartolomei 2013], by the census of historical premises in the Marche [Regione Marche 2014], which led to a dedicated guide, and finally by the census and photographic guide of the historical places of commerce and catering in the Veneto, from which the app *Veneto su misura* was produced.

Among these initiatives is the activity of the research team of the Department of Civil and Environmental Engineering of the University of Perugia. With regard to the case study of the historic centre of Spoleto, in the context of the initiative *Consulto su Spoleto* (2017), starting from the analysis and highlighting of the critical points of the Building and Town Planning Regulations, the aim is both to draw up a census and typological analysis of the commercial activities present along the streets of the historic centre, and to identify a series of criteria to guide planning choices, also through the promotion of city branding actions. The question as to which instruments today allow for the protection and, above all, the enhancement of historic commercial activities has not yet found an unequivocal answer; in fact, the debate, at times polemical [Adinolfi 2016], on the opportunity of fluid reallocation of protected commercial spaces to new brands, even related to product categories very distant from the original destination, is still open. A controversial case in

this regard is the Santa Maria Novella railway station in Florence, a protected work by Giovanni Michelucci, where the relocation of commercial activities has meant that a brand of underwear has found a home in the former offices of a bank and a supermarket has moved into the space originally dedicated to worship. Although this stratification may create an interesting ambiguity in some respects (in this case, the overlapping of signs does not seem to be a reason for disorientation, but rather highlights the vitality of a place able to update and renew itself over time), the problematic knot of the ephemeral margin between protection and reuse remains open.

The Shop as an Experiential Theatre

In light of these considerations on the identity character of the historical shop, with the aim of its enhancement in contemporary terms, it seems necessary to question the meaning it currently assumes. In other words, it is necessary to acquire a new awareness of the concept of 'shop', a concept that has undergone deep changes over time and is constantly evolving. In this context, it assumes nodal importance to investigate the opportunity offered by the use of New Technologies, with specific reference to AR and AI, also as an evolved strategy for the protection of the material characteristics of places, given the current conception of the physical retail space [van Escha et al. 2019]. Increasingly, the shop is not only a material place to buy products, but it becomes the 'emotional centre' through which communication between the brand and its target audience takes place [Taylor, Zavoleas 2018]. With the spread of e–commerce, in fact, it is possible to buy anywhere and with just a few clicks: the relationship between buyer and product is mediated by a device and, in this sense, requires that the customer's involvement takes place at other levels and through different channels. The physical shop, on the other hand, has to offer a different experience to e–commerce, possibly personalised and user–centred, capable of including those elements of memorability and engagement that determine both diversification from computerised purchasing and an effective support to it. For example, in today's advertising policy, the flagship store represents an investment whose profit is estimated in terms of advertising rather than on–site sales to the consumer. The store becomes almost an advertising space, similar to that available in publishing, television or other media. The objective underlying this dynamic is the evolution of the consumer's role into that of 'consumer–actor', as the user, having identified with the brand and recognised its values, becomes its ambassador and testimonial. The physical shop, both through the architecture of the place, the design of the interiors and of the retail space, and through communication actions and an increasingly advanced use of technology, becomes the scene of a user experience aimed at the progressive discovery of the brand through strategies of engagement, customization and strengthening of the community [Riewoldt 2002, Marchetti 2009]. The objective of engagement is to involve the user in an immersive experience, whose location par excellence is the physical shop: dedicated entrance, shop window and room/corner are the nodal points of the connection and emotional exchange between user and brand. An emblematic example, which embodies this branding strategy through AR applications, is represented by the Nike flagship store in NY, where there is a 'Running Trial Zone' that allows visitors to test the most suitable shoes for jogging and competitive running on a treadmill facing a wall/screen that simulates the immersion of the runner in Central Park. The aim of customisation is to offer the user a personalised and customisable experience; the shop respects and satisfies the diversified needs of a multiplicity of customers, proposing distinct paths according to the type of user. There are numerous examples of this strategy: from the *Fragrance Lab* (multi–sensory interactive areas for personalised fragrance exploration and product customisation) in one of Selfridge's London locations to the *Hunter pop–up* (an interactive and immersive greenhouse designed as a test room to simulate the use of clothing) installed in NY Central Terminal. Finally, the aim of the community is to use the physical location of the shop to build user involvement within a 24/7 connected community through events, gamification, contacts and sharing. The architecture and scenery of the store become a source of wonder and an object of sharing; digital communication makes the spread of the brand, its values and therefore, its products viral through the users themselves. In this sense, the example of the Samsung 837 store NY is emblematic: a multifunctional store, which incorporates, in addition to its usual function as a

shop, those of a theatre, cafeteria, museum, games room and, last but not least, a multimedia tunnel for an immersive experience, whose external transmission is entirely entrusted to the sharing of selfies by users/ambassadors on their social profiles [Galasso n.d.].

The Shop From Identity Value to Experiential Theatre

The proposed reflection intends to focus on the potential offered by the use of the described strategies in historical commercial contexts, where the brand can adopt an approach that allows it to take further advantage in commercial terms of the acquisition of the identity and historical–artistic value of the location. From this point of view, the '*bottega*' becomes an ideal field, in which the combination of tradition and technological innovation can generate innovative commercial methods capable of implementing a mutual and synergic enhancement between brand and physical shop. There are numerous examples of this: just think of the case of the recovery and redevelopment of the former Agip station in Piazzale Accursio in Milan, originally designed by Mario Baciocchi on commission from Enrico Mattei and converted in 2017, by Michele De Lucchi, into 'Garage Italia', a shop that welcomes the new destination by reinforcing its identity connotation. Then there is the case of the 'Starbucks Reserve Roastery Milano', where the brand adapts its image by declining and lowering it into the cultural background in which it is inserted. How can an American coffee be competitive with espresso, a product deeply rooted in the daily life of the '*Belpa*ese', whose violation seems almost sacrilegious? The strategy adopted by the international brand in Italy, the home of coffee, is 'to be Italian': first of all, by choosing the historic location of Palazzo Broggi (built in 1901 in Piazza Cordusio, the heart of Milan's financial district, and formerly the headquarters of the Stock Exchange and the Italian Post Office from 1998 to 2011), then by adopting the style of a former coffee roasting and establishing a partnership with the Princi pastry shop, a local excellence, and finally by offering immersive experiences ranging from the inhalation of fragrances to the consultation of content on demand through AR. Another significant case is represented by 'Galeria Melissa' in New York, where the immersive experience allows continuous changes of setting and entertains customers through interactive facades and user profiling through AR and AI. In this case, the importance of the shop window in the operations of 'augmented reuse' clearly emerges: from a simple place of display, it becomes a screen, a portal, an intelligent interface between the brand and the user. The formula AR+AI=Augmented (Retail+Identity) appears in this scenario to be the synthesis of a specific approach, which consists in using AR and AI technologies as a tool to reach a concept of 'augmented historical shop' in its identity connotation. Moreover, with the added value represented by the possibility of implementing a variety of scenarios and installations without materially altering the existing morphology, a particularly virtuous potential in the redevelopment or conversion of historic commercial spaces. In this sense, AR and AI are a vehicle for "a mobilisation that looks to the future and not to the past, which sees the shop as a paradigm of a multifunctionality that only the tools of the contemporary world can offer and of which young people are the main and privileged interpreters" [Petrini 2020].

A Case Study: Barbieria Lolli in Perugia

This is the context for the design proposal to transform Barbieria Lolli (a historic commercial activity on Perugia's acropolis owned by the University of Perugia) into an augmented university store. The interior walls, among the few surviving frescoes in the city, are the first work of the Perugian painter Napoleone Verga (Perugia 1833 – Nice 1916) [*I luoghi dell'Università* 2008; Boco, Ponti 2006], who painted them "in the style of the XIV century" [De Gubernatis 1889, p. 542]. The need to preserve the painted surfaces by avoiding contact and the small size of the shop (which has a single opening on Via Mazzini, a side street of Corso Vannucci, the city's main street) make it an ideal opportunity to intervene with AR tools, assigning an interactive filtering role to the shop window. The idea is to transform this precious historical and artistic asset into an experiential theatre able to convey the renewed identity of the University of Perugia. In line with the relationship between tradition and innovation, which is one of the core values on which the University of Perugia's communication is based, a transparent LED wall will be inserted in the space occupied by the fixed glass surface along the street. Without losing the relationship of continuity between inside and outside,

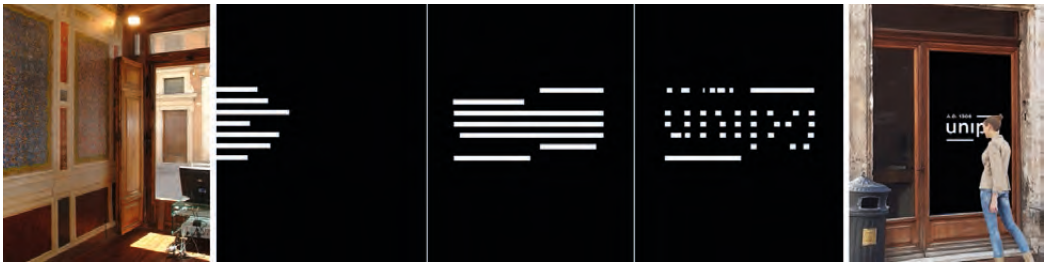

Fig. 1. Barbieria Lolli in Perugia, the interior of the historic shop (left) and the project of the new interactive shop window (right).

the showcase is conceived as a virtual surface subject to continuous changes thanks to the interaction with passers–by, offering illusionistic experiences in the space of everyday city life (fig. 1). The new shop window is set up on the basis of factors that do not strictly concern the enhancement of the material goods on offer, but as a device for activating the identity value of the University of Perugia (conveyed by the new logo) while protecting the historical character of the place.

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New Interpretative Models for the Study of Urban Space

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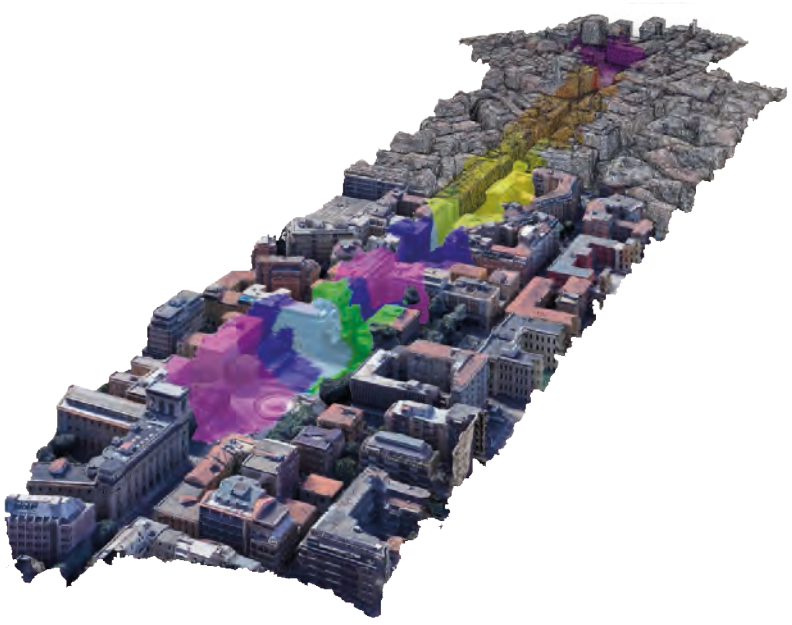
Abstract

The research project aims to acquire data on the impact of an environment on humans. The process is based on the use of the EEG helmet synchronised to GPS: the EEG helmet is a device that non–invasively records 14 channels of the human brain through electrodes and, through an algorithm, transforms them into cognitive states in real time. Starting from this raw data, through the 'circumplex model', cognitive states can be transformed into emotions with the aim of showing what people on average feel in a given urban space. The data, which are linked through GPS to a position in space, are empirically recorded with statistically significant samples from which emotions are reprojected onto the mesh of the digitally reconstructed environment through a process of photomodelling.

Keywords
perception, EEG, GPS, representation, emotions.



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Introduction

If the theme of landscape is of great topicality, it is perhaps because, in its ethereal form, it represents the best contemporary utopia that is content to classify and circumscribe the problem of the relationship between man and the world around him, with the value of images, but without seeking solutions: by amplifying the distance between reality and its ideal model, there is often the risk of hiding the cultural and instrumental deficiency in the interpretation and representation of current phenomena and the strong current impediments in the construction of contemporary landscapes. This concept does not correspond with the concept of place, territory, environment, panorama [Bianconi & Filippucci 2019], but as the European Convention formalises, "Landscape" means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors. The idea of landscape is therefore a cultural process, closely linked to perception [Arnheim 1986], to vision [Kepes, Rossi Chiaia 1990] and to those elements that structure the processes of identity construction.
Man, immersed in the built environment, is very often unaware of the influences it exerts on him. Generally, people gravitate towards spaces that may not be psychologically stimulating, but through habit tend to prefer a usual and known, albeit imperfect, pattern, rather than other configurations that would bring greater benefits from the point of view of psychophysical well–being and therefore identity. Even though most of our experiences in our surroundings do not take place consciously. In general, however, there is no such thing as a 'neutral' environment in an urban context: from the point of view of health, the man–made environment necessarily brings benefits or discomfort, contributing in the latter case to the onset of psychophysical illnesses. The built environment either helps or hurts [Goldhagen 2017], but design cannot be directly aimed at the health of citizens [Millennium Ecosystem Assessment 2005] and their well–being [Bechtel, Churchman 2002] if there is no methodology to analyse and evaluate the effects of solutions, then considering the social dimension of the individual's life [Schram–Bijkerk et al. 2018].

Research Themes

The research aims to study the survey of landscape qualities [Bianconi, Filippucci 2018]. The innovative aspects that characterize the research can be identified in the digital path developed aimed at the construction of interpretative tools of the relationship between the environment and its impacts, represented on the space. The analysis of people's behaviour in public space is developed using advanced digital tools and biosensors such as the EEG helmet. This makes it possible to define analytical and scientific data on feelings, by interpreting them it is possible to interpret the essential elements that influence well–being through the emotional state. The neuro–headset data makes it possible to understand which part of the cerebral cortex is affected by certain signals when immersed in an environment, thus providing interpretable data that is also useful for hypothesising solutions in compromised urban contexts. The EEG helmet is a device that non–invasively records 14 channels of the human brain through electrodes and, through an algorithm, transforms them into cognitive states in real time [Kim et al. 2018]. This is functional for behaviour analysis [Aspinall et al. 2015; Chynal et al. 2016; Tachi 2012; Yadava et al. 2017]: in fact, the raw data collected on brain impulses are interpreted by algorithms and transformed into six cognitive states (valence, arousal, stress, meditation, focus, engagement) [Badcock et al. 2015; Kotowski et al. 2018]. In the developed pathway, the combined use of the data is achieved through the circomplex model (fig. 4) [Posner et al. 2008] that allows emotions to be calculated using only the cognitive states of valence and arousal [Yik et al. 2011]. With the valence value as the first polar coordinate and the arousal value as the second polar coordinate, it is possible to obtain a point within the circumplex model that represents the emotion of the observer. These points are associated with a unique colour vector for each combination, transcribed in RGB colour space. In addition to the EEG data, the geographical position is acquired in real time at a regular interval of one second; thanks to the timestamp, it was possible to synchronize the GPS and EEG data.

The experimental route leads to the collection of data on the position and cognitive states of several testers. It was therefore necessary to find a way to compare the emotions of different testers according to their spatial position. By means of an algorithm developed in the visual script language Grasshopper for the Nurbs environment of Rhinoceros, it is possible to import CSV data of the experiments containing synchronised coordinates and EEG data and identify at which positions the observations were taken from contiguous and thus comparable points. The developed algorithm [Bianconi et al. 2019] [Bianconi et al. 2020] then identifies the comparable recordings and calculates the average of the EEG and GPS values belonging to the same cell; in this way the average of the observers in space is obtained. The representation of the data is possible using as a base a mesh model of the territory (DEM) under analysis; the model is obtained through a process of photomodelling via google earth pro photos with 3d buildings enabled. An attribute is added to the mesh base at each vertex, which corresponds to an RGB vector representing the average value in the circumscribed model of the sensation felt by the observers. Finally, the faces of the mesh are coloured by interpolating the vertex colours in a linear fashion. The representation thus obtained has a double objective: to store the instrumental data and to represent them in a comprehensible way (figs. 2-3).

Fig. 1. The research area. The centre of Terni.

The Case Study: Terni City Centre

An illustrative case that shows the value of the analyses are the studies carried out in a portion of the historic centre of Terni that from Piazza Tacito, across the Corso, reaches Palazzo Spada (fig. 1). The area under examination constitutes a section of considerable interest because within it there are many peculiarities. In an extremely circumscribed space there is a pedestrian area, intersections with roads, a square with a recent arrangement of street furniture and a square with an important Renaissance palace. And it is precisely the way in which these elements influence the emotional state of the user that is the subject of the analysis in question.
From the data acquired and processed it emerges that the area can be divided into four zones according to the emotions aroused in the observers. At the starting point, on average,

a feeling of strong stress emerges due to the area highly congested with car traffic; continuing, the pedestrian area represents an area that oscillates between serenity and calmness except near the intersections with the driveways. In the final part of Corso Tacito a gradual transition from a state of calm to a high degree of stress in the vicinity of Palazzo Spada is clearly visible. This analysis shows that the pedestrian area of the city's main street is perceived as a comfortable space for users, but the fact that it is located between two highly trafficked squares limits its potential.

Conclusions

The proposal aims to define methodologies for data collection and interdisciplinary interpretative criteria to understand the impact of the environment on man, with the implicit objective of being able to direct design choices to build places that create wellbeing.
With an interdisciplinary approach and through the integration of multiple devices for detecting perception, it is possible to analyse what people feel and understand how the environment implicitly influences their emotional state and which places and conditions promote wellbeing.
Digital becomes a true Computer–aided Design tool, with digital data used not only to show the visible but also to make visible what is implicit in the relationship between man and the environment. The aim is thus to conform an innovative methodology that supports an operational verification of the meaning of places, which analytically focuses on emotions and meanings and can be used as a strategy for studying not only the territory and the environment, but also the landscape, understood as the result of the perception process. The creation of new data and their representation are the basis of new methodologies of investigation through the use of AI for the design and optimization of urban spaces.

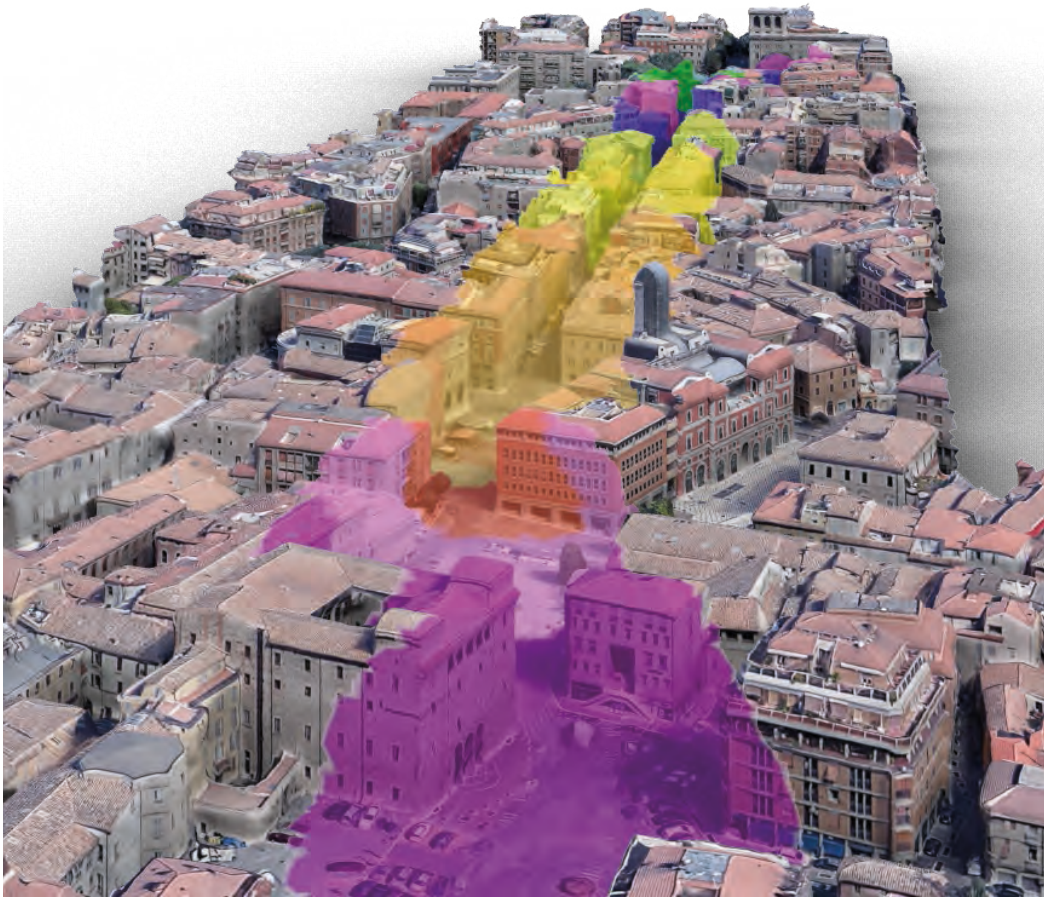

Fig. 2. Processing obtained through the developed algorithm. Each colour represents an average emotion felt in space.

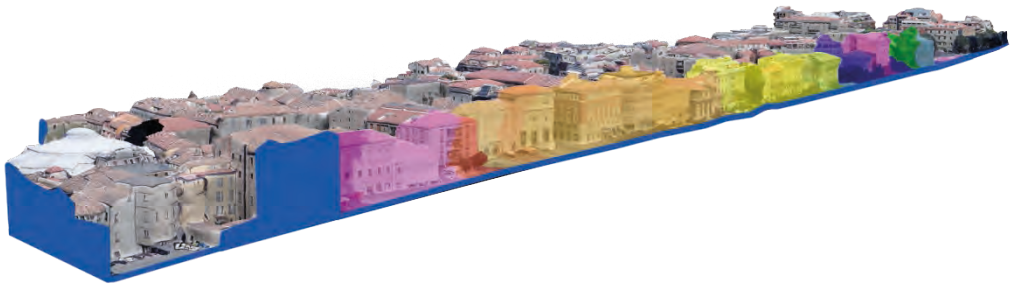

Fig. 3. In the perspective section, one can see the division of the average emotions felt during the experiment.

Fig. 4. Via the circomplex model is to represent through the colors the emotions.

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Augmented Reality as a Research Tool, for the Knowledge and Enhancement of Cultural Heritage

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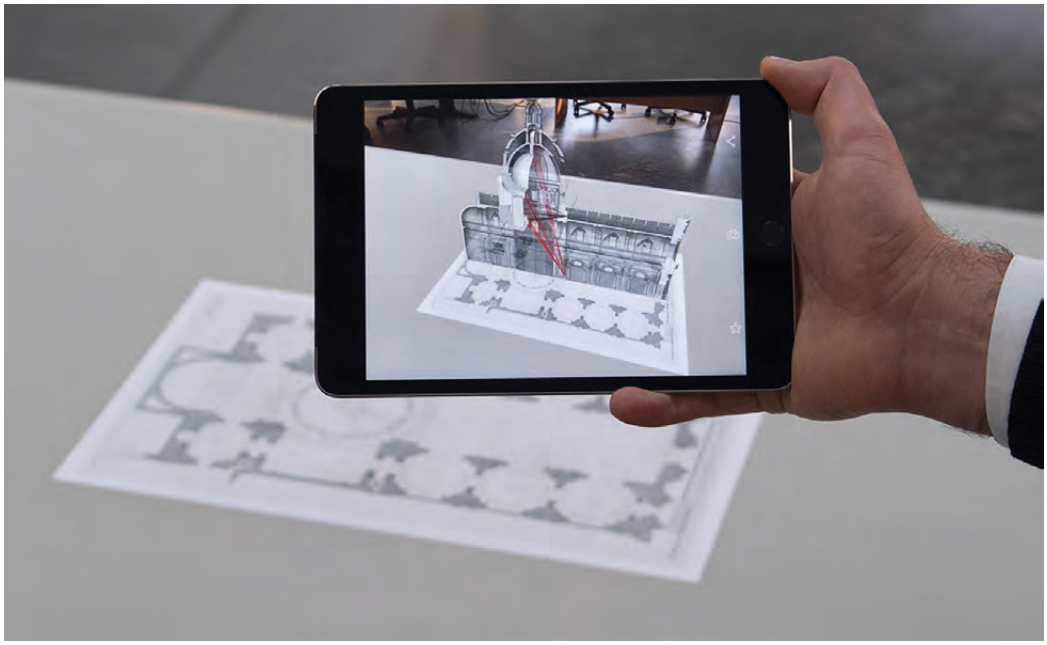
Mauro Saccone
Antonio Camassa

Abstract

Starting from a reflection on the new role of digital technology in this pandemic situation, and particularly the role of AR for Cultural Heritage, this paper presents two AR applications. The first is used to share the analyses carried out on the Pantheon surveys realized between the seventeenth and nineteenth centuries. The second is about the illusionistic dome in the Church of Sant'Ignazio in Rome, realized by Andrea Pozzo. These two applications can display three–dimensional models superimposed onto images and original drawings, and also two–dimensional contents: the results of graphical analysis carried out on digital copies. The final aim of this ongoing research is to develop some AR multimedia content, linked to semantic concepts.

Keywords
augmented reality, cultural heritage, geometric analysis, 3D survey.



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Premise

This last year, with the restrictions due to the Covid–19 pandemic, the growth of digital technologies, applied to activities related to cultural heritage but which cannot be accessed physically, have accelerated in an unprecedented manner, thus generating innumerable spawning of network applications, a kind of "digital golden rush" [Concas 2021, p. 15]. A profound evaluation and reformulation of digital methodologies and technologies are thus deemed necessary, for they have led to a turning point, a kind of "destructive innovation" [Santamaria 2021].
Virtual, mixed, and augmented reality have all become common terms in recent years. However, the relationship between real and virtual is not only of interest at present. Since the 1990s, Tomás Maldonado initiated reflections on the theme of the relationship between the real and the virtual according to which a (real) painting prefigures a space of the (virtual) pictorial scene, in a relationship that transcends the boundaries between space and time [Maldonado 1995, p. 162]. In this context, some examples are the eighteenth–century views of the historic center of Dresden by Bernardo Bellotto, in which the space depicted in the (virtual) painting is used as a reference model for the post–war reconstructions (real) of the old city, destroyed in the 1945 allied bombings. The same space–time relationship is evidenced in a 2016 installation, where the view of Dresden from Elba's right bank depicted in a 1748 painting (virtual) by the Venetian painter is viewed within an empty frame (real) [Dal Pozzolo 2021, p. 145].
Augmented reality certainly represents the most appropriate digital tool to permit the observer to move within a hybrid space, that is physical and virtual. Already in 1995 [Milgram et al. 1995], Augment Reality (AR) was situated within a space defined as a Virtuality–Reality Continuum, and delimited by two extremes, the real and the virtual world. According to the definition by Nofal [Nofal et al. 2017], AR moves within a hybrid space (called Phygital, a fusing of the terms physical and digital), where the boundaries between physical and virtual space are not necessarily clear or defined, thus delineating various degrees of AR and varying uses of virtual contents. These can be described according to three typologies:
1) the first type, multimedia, where information related to an object, physical and real, are connected through various media (texts, images, data);
2) the second type, hybrid, to the real object, a two–dimensional print or drawing, are connected data and models, which may themselves be two or three dimensional;
3) the third type, three–dimensional, to the real object, that is the physical space enveloping the observer, data and virtual 3D objects are superimposed. This represents the most advanced level in the use of AR.

Fig. 1. Over the drawings, side menus show the main themes of comparison.

Introduction to AR Applications

The applications described in this article are at a stage prior to the final aims of the research, but present interesting results with potential developments yet to be explored. These applications integrate the usual display mode of three–dimensional models superimposed onto images and drawings with two–dimensional contents, that is to say, the results of graphical analysis carried out on digital copies.
The fundamental issues in these types of applications are related to the need to be able to identify a rational selection and synthesis of the scientific contents to be displayed which, though necessary, given the effectiveness and distinctness of the means of communication used, must not compromise the scientific result. The project [1], whose initial report is presented here, addresses these issues by identifying in each of the themes presented, the narrative lines of the contents, allowing different levels of detailed studies, through a sharing of information that is gradually more complex, to meet the diverse interests of distinct users [2].
From a technical point of view, the applications were developed on a platform that simplifies the AR experience project, is compatible with all kinds of devices [3], and guarantees sufficient accuracy in the overlap of various levels of information. Its versatility has allowed an *ad hoc* development, addressing the categories of possible users and the sites where the AR experience may be employed.
The two applications, described below in detail, refer to two different contexts but share the same objectives: to convey unusual items of knowledge, perhaps not easily understood immediately, but that aim to show how the drawing and the use of AR technologies can reveal the geometries underlying the apparent forms, and also bring them to the attention of the general public and stimulate the more inquisitive ones to research further, in more appropriate locations.

AR–Pantheon: Survey and Drawings

The objective of the first application was to use AR to share the analyses carried out on the Pantheon [4] surveys realized between the seventeenth and nineteenth centuries, in particular the studies carried out by the *pensionnaires* of the Académie des Beaux Arts in Paris and by the students of the Academy of San Luca in Rome. An analysis of the survey drawings tells us how, over time, the architects looked to antiquity, allowing them to consolidate their knowledge on the construction and conservation history of the monument. Consulting the original drawings in the archives of the aforementioned Academies [AABA] [Marconi 1974] made it possible to closely analyze the documents to identify the marks relating to the construction lines and the holes of the compass points.
The 3D survey of the Pantheon, achieved through the use of integrated systems (photogrammetry and laser scanner), made it possible to carry out an accurate comparison between the archival drawings and drawings of their present state.
The results of the analyses and of the superpositions were processed so they could be displayed by the AR application (see note 3), which uses marker–based tracking technology [Bekele 2018, p. 5]. The application was realized with a dual purpose: on the one hand, the possible use in an exhibition of the drawings of the Pantheon, on the other, directly in the archive, to show the analyses carried out, superimposed over the original drawings. The application can also highlight the different interpretations of the geometry of the Pantheon and the transformations undergone in its transition from an ancient monument to a church.

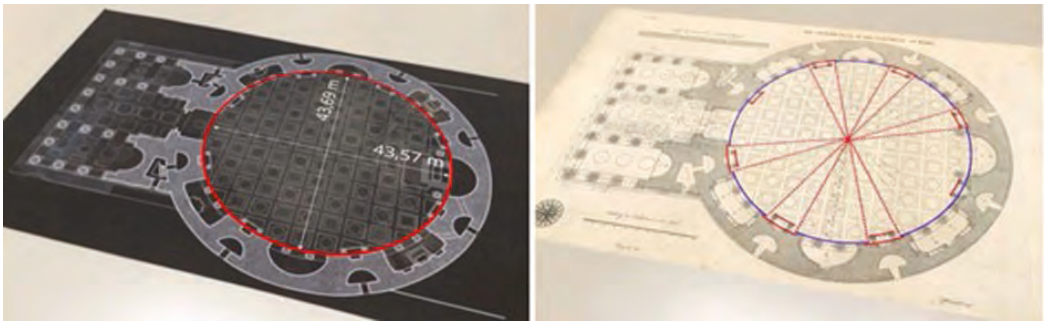

Fig. 2. Desgodets' interpretation of roundness versus 3D survey: our comparison.

When the drawings are displayed, AR side menus (fig. 1) introduce the main items, such as the geometry and size of the Pantheon dome, to compare how the different authors of the various survey drawings interpreted them (fig. 2).
Thanks to the use of geometric elements (the circumferences, axes, tangents, etc.) and three–dimensional models (the cylinder and the sphere) superimposed on the plans and sections, our augmented reality application summarizes – by relating the drawings in space, the plans (virtual) and the sections (real) – the different analyses of the monument that the architects of the past carried out.

Andrea Pozzo Augmented Perspective

The second application refers to the illusionistic dome in the Church of Sant'Ignazio in Rome, the work of Andrea Pozzo (1642-1709) [5].
The development of an AR application on this theme began with a consideration of the spatial location of the canvas depicting the illusionistic dome (fig. 3) horizontally situated 32 meters above ground, at the intersection between the nave and the transept of the church of Sant'Ignazio in Rome. The canvas, simulating a real dome in perspective, is correctly visible from a preferential point of view indicated on the ground by a marble disc, which allows visitors to comprehend the perceptive artifice. The technique used (tempera), over time, has developed a blackening of the pictorial surface [6] so that one cannot appreciate it as it would have been in 1685, the year it was installed in the cross–vault. So an AR application was developed, with the intent to convey not just the wealth of details of the painting but above all the perspective scheme that allowed Pozzo to compose the illusionistic dome. Thanks to a simple setup of two display panels (fig. 3), the application allows an augmented interaction with a scale reproduction of the painting.
The application is divided into three sections: users can choose the content according to their interests on the subject selecting different levels of information detail.
In the section 'artistic historical research' one can compare different works of illusionistic domes ascribable to Pozzo, collated in the different phases of the historical–archival study. Thereby offering the possibility of partially superimposing over the marker, depicting the painting, the drawings and sketches of other illusionistic domes by Andrea Pozzo, compared instantaneously thanks to the virtual space of the AR.
In the 'surveys' section, it is possible to view, aligned with the marker, the high–resolution photo, to analyze the pictorial consistencies of the architectural elements of the work down to the smallest details, which are otherwise invisible when viewing the original, given the height at which the canvas is placed.
The section 'geometric analyses' contains the graphic elaborations carried out on the painting, beginning with the study of the two methods that Andrea Pozzo describes in the two volumes of

Fig. 3. Left: Church of S. Ignazio, Rome, interior; right: a demo of the use of the AR application "AP_Andrea Pozzo_ Augmented Perspective".

his treatise *Perspectiva pictorum et architectorum* (Vol. I 1693, Vol. II 1700). Several layers gradually are superimposed over the marker, evidencing the perspective restitution operations carried out to retrace the architectural section from the perspective drawing.
With the application, one can visualize a section of the model of the church and relate it to the plan (fig. in front page). The aim of the model is twofold, to represent the church with the virtual reconstruction of the dome designed by Pozzo and at the same time show the perspective method underlying the same restitution by retracing, in reverse, Andrea Pozzo's *modus expeditissimus*.

Conclusions

These two case studies show how we have used AR to share the analyses carried out on drawings and canvas. In the future, this kind of application should integrate databases organized according to semantic structures [Canciani 2020], which can connect related research fields. Our aim is to develop on–site AR applications, using markerless tracking, to introduce 3D models as well as two–dimensional contents surrounding the users.

Notes

[1] Working on the project is the research team of the Department of Architecture (Roma Tre) consisting of M. Canciani, G. Spadafora, M. Saccone, A. Camassa, in collaboration with the ENEA research team coordinated by M. Mongelli.

[2] It is understood that the level of detail proposed in the project is consistent with the methods designed for these two particular AR applications.

[3] The commercial application used is blippAR®.

[4] Selected were some of the results of the doctoral research: *Disegnare il Pantheon. La pratica del rilievo nell'insegnamento accademico del XIX secolo e nel disegno digitale contemporaneo* presented by Mauro Saccone in the XIX cycle of Architectural Doctorate: innovation and heritage (tutor Marco Canciani).

[5] The application presented here draws on some results of the doctoral research, currently being completed, *"congiugnere il finto col vero" – Geometria e architettura nella finta cupola di Andrea Pozzo a Roma*, presented by Antonio Camassa, XXXIII cycle of the Architectural Doctorate: innovation and heritage (tutor Giovanna Spadafora).

[6] As the early 18th century, the illusionistic dome was not visible, as reported in [Montalto 1962].

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Augmenting Angri: Murals in AR for Urban Regeneration and Historical Memory

Alessandra Pagliano

Abstract

Augmenting Angri is a project aiming at preserving the memory of about twenty murals located in the historical centre of the small city of Angri (SA) using ICT and in particular Augmented reality. The project has been carried on in 2020 with the students attending the integrated course of Visual Expression (professors A. Pagliano and P. Vitolo) in the Master's Degree Course in Design for the Built Environment.
Augmenting Angri consists of an innovative valorisation path in Augmented reality which expand the narrative message of the old murales thanks to the digital contents (audio, video, animations and 3D models), sometime replacing them back, in case of totally disappeared murales.

Keywords
street art, augmented reality, cultural heritage, artivive, murales.

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From Graffiti to Street Art in Contemporary Cities

Street art emerged as an artistic practice since the 1960s in the United States, in form of graffiti, namely the tags of the writers who usually are young people from degraded suburbs who leave a testimony of their problems on empty walls, thereby performing an unauthorised and illegal action. Today, street art has evolved considerably, abandoning graffiti in favour of painted images, often characterised by a high artistic quality, which has attracted the interest of critics and art historians, becoming today one of the most established forms of urban art.

Abandoned or degraded spaces are enhanced with fast, low–cost and high–impact interventions that sometimes become the spark and the starting point for a following physical redevelopment and social regeneration. In the abandoned places, in the residual spaces [Bauman 2002], in those buildings without any quality and in the so called 'non–places' [Augé 1996], urban art is a powerful tool capable of reopening the dialogue with the urban context through imagination, transforming these inexact spaces into active elements of the urban and social landscape. The modification of an abandoned space through urban art intervenes on the cultural and perceptive aspects capable of influencing both the physical space and the inhabitants' habits, superimposing new signs on the pre–existing ones and thus creating a 'new space' through the interaction of the physical volumes and the illusory appearance superimposed on them. So, the murals adopt those walls, transforming and offering them a new role in the surrounding space. The shape, size and subject of a mural are thus a spatial response to a latent urban question.

When murals are socially accepted for their aesthetic contribution to the urban environment, the city appropriates the works. In such circumstances, citizens strongly assert their need to own and preserve these artworks, requiring them to remain. The request for conservation and permanence emerges *a posteriori*, thanks to a slow process of social recognition of their value.

But the problem related to the maintenance of murals is an ongoing issue, which goes from the recognition of the mural as an artwork to the need for its protection in order to preserve and pass on its value to future generations. The painter holds the paternity but not the ownership of the artwork, since it was painted it on other people's walls. Therefore, street artists are used to accept the temporary nature of the artwork itself, probably destined to be removed by the will of the real owner of the wall. Even in case of famous artists, transferring murals to museums is inappropriate because the very meaning of the mural would be altered if removed from the urban context which generated it, but also because it could be done against the will of the author, who instead generally accepts his/her artwork to be perishable.

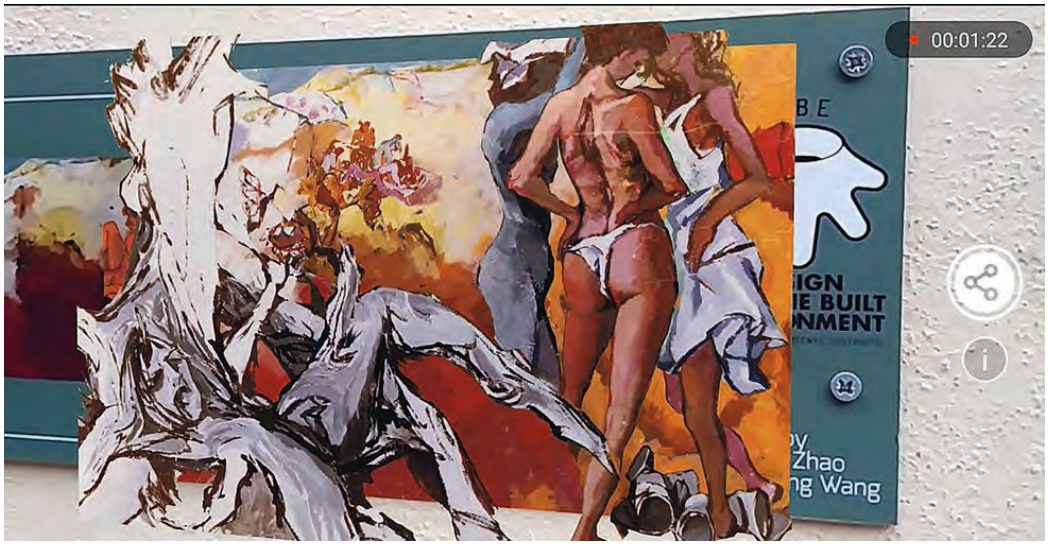

Fig. 1. Augmented digital contents for the mural of Vittorio Miranda, today disappeared, screenshot from the app.

Street art is always exposed to the ever–changing conditions of the street and It's quite impossible to protect murals from the rain, snow, direct sunlight, or intense cold; protecting a street artwork, as in the very debated case of Banksy's mural in Via dei Tribunali (Na), recently covered with a glass that protects the painted image from the weather, profoundly alters the inner nature of a street mural.
This suggests that street art cannot be assumed as "finished" artwork, strictly linked only to the author, because the constant exposure to change is its inner nature and, perhaps, the only real way for it to remain authentic.

Augmenting Angri: Augmented Reality to Valorize the Murals

In terms of street art's protection and heritagization, the lack of defined and consolidated guidelines, due to both the high variability of the materials used by artists and the issues related to the ownership of works, produces an immobility that is far more damaging than the weathering itself.
Augmenting Angri is a project aiming at preserving the memory of about twenty murals located in the historical centre of the small city of Angri. The project has been carried on with the collaboration of the students attending the integrated course of Visual Expression (professors A. Pagliano and P. Vitolo) of the Master's Degree Course in Design for the Built Environment. The area of the old Angevin village is formed by two orthogonal streets that shap four insulae. The road axes are named according to their orientation with respect to the cardinal points (Via di Mezzo Sud, Via di Mezzo Nord ...) and extend close to the medieval castle. The murals in the Vie di mezzo were painted between 1982 and 1983 and constitute a pioneering urban art project, to bring collective attention back to the cultural value of Angri's historic centre, which was suffering from serious deterioration and subsequent abandonment after the 1980 earthquake.
The initiative was promoted by the municipal administration. Twenty artists, led by Gianni Rossi, transformed the four streets into an open–air gallery, by painting murals of various sizes and different subjects, which were inserted on the facades according to a variety of ways, in order to suit the morphology of the walls, with windows and doors instead of treating the facade as a blank canvas. The artists acted as spokesmen for the collective and personal malaise of the post–earthquake years, or in other cases they represented the most characteristic elements of Angrian identity, such as the agricultural vocation, deep religious devotion or local historical episodes.

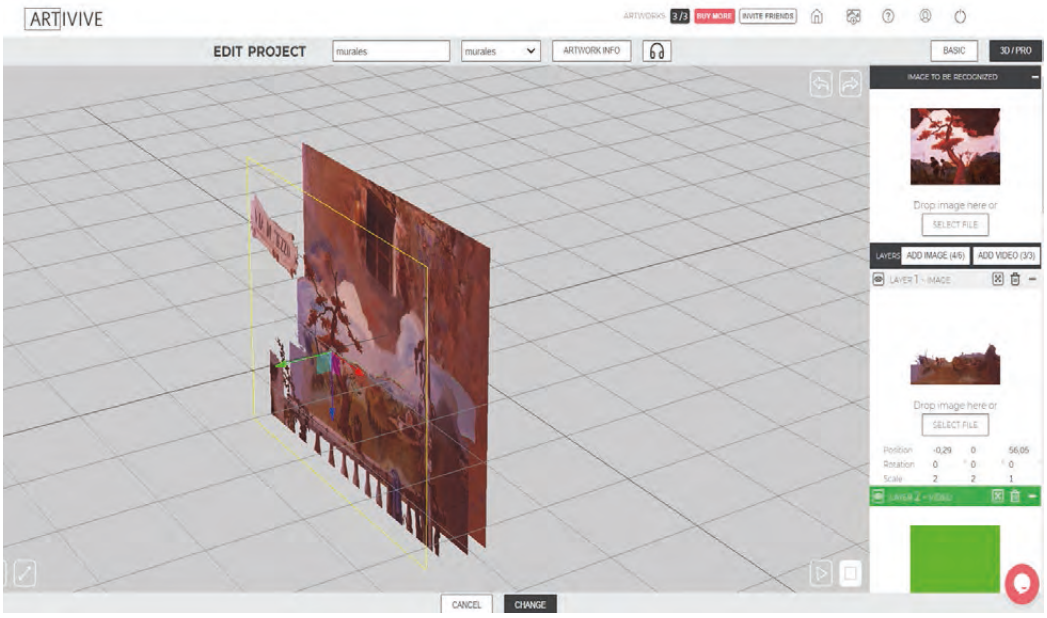

Fig. 2. Giving a new interactive depth to the painted image in the Ativive bridge app.

Severely degraded, very little remains today of the original murals, but a good photographic documentation and the potential of digital technology have enabled us to re–propose each mural in the original locations, bringing them to life by means of short animations. In some cases, they totally disappeared, completely erased by the renovation of the building facades: in fact, some owners took over the buildings when the mural was at an advanced stage of deterioration and they were unable to perceive original artistic value and the role that the mural had for the collective memory. They simply identified them as signs of decay and removed them.
In our Augmenting Angri project, since it was not possible to carry out a pictorial restoration of the still remaining painted images, and since we also did not consider appropriate to remake (re–paint) those which completely disappeared a long time ago, the request of those places was immediately intended in a need to preserve the memory of that fruitful interaction between the beauty of the murals, their social message and the urban regeneration that they activated in that concentrated urban context. We designed an exhibition path supported by small printed panels, directly affixed to the façades and containing some markers activating augmented reality contents; in this way it was possible to bring the disappeared murals back to their original location. All the remaining murals, in most cases only partially visible, were reproduced in their original state, also enriching each artwork with additional narrative contents. Augmented reality digital contents, superimposed to the physical reality, create a surprising relationship among three different spatial dimensions: the perspective space represented in the mural, the digital space of the augmented content and the real one of the urban environment that is physically experienced by the public. Thus, each observer becomes an active subject of his/her own individual knowledge process according to a dynamic cognitive path. New digital technologies are in fact restructuring the relationship between experience and knowledge. In spite of the need to re–propose in those places the painted images that have now disappeared, the digitisation of the murals was not intended as a reproduction, a digital copy, even if faithful and accurate, but as the generation of a new mixed asset (both digital and Physical) that provides further knowledge. Ben Hicks defines this new digital asset as 'digital twin', remarking the differences with a simply digital prototype or model "as an appropriately synchronized body of useful information (structure, function, and behaviour) of a physical entity in virtual space, with flows of information that enable convergence between the physical and virtual states" [Hicks 2019]. According to the previous definition, digital twins in not a mere copy of the real object but a new object with data, functions, and features of the real one but added by the communication capabilities of the digital world. The reconfiguration of the cognitive process, typical of digital technologies and in particular of augmented reality, takes place only when the digital contents are experienced and lived, i.e. 'activated', by an observer. In fact, the designed semantic link is enabled and implemented only through individual interaction and experience with the designed knowledge contents. Today, the ability of cultural heritage to arouse emotions, establish links and stimulate curiosity can become effective if we take into account that contemporary users have completely changed: they are both 'digital immigrants' and 'digital natives' with different expectations, pre–existing knowledge, historical/cultural backgrounds and interpretative strategies. The students of the Design for the Built Environment course were encouraged to address their project to this new audience, uncovering the evocative power of each mural to develop and enhance its storytelling. The narrative aspect is, in fact, a good binder to combine emotions with information. Murals' painted scenes are the representation of a single moment, which remains eternally frozen and which the artist subtracted from a long–envisioned sequence of gestures and positions, by painting a crystallised motion. Each image has been analysed for its ability to suspend time with a hinted gesture, a gust of wind, a fleeting glance, a facial expression that become permanent. In this way the time is allowed again to flow before and after that suspended portrayed moment. The brief animations, designed to give life to the static painted scene, are slight variations of the portrayed configuration, as a simple temporal expansion of that moment. Augmented reality allowed us to integrate or change the state of each mural without compromising the physical state. The link between AR and murals' visual and pictorial aspects required a deep

disciplinary study in terms of representation as a possible product of new ways of looking at reality, new perceptions and therefore new ways of interacting with perceived space.
Furthermore, the images of the Angrian village murals were also interpretated according to the category of the painted three–dimensional spatiality that regulates the reciprocal positions and distances between objects, background, architecture and the human characters acting there. The perspective space has been made interactively explorable again, beyond the point of view chosen by the artist, thanks to augmented reality, which allows the viewer to enter the space portrayed in the pictorial image thanks to the three dimensions restored to the mural in the virtual space. Each mural has been provided with a thin horizontal band, containing three printed images designed to be "markers" for digital content activation. By scanning one by one each marker with the open–source app *Artivive*, different digital content appear on observer's smart device: a short video clips narrating artist's life and poetry, an animated storytelling of the painted image and a three–dimensional model drawn according to parallel planes which, like a theatrical scenography, gives the perspective image a virtual three–dimensionality and an explorable spatial depth.
Augmenting Angri won funding from the Open Call Street Art 2020, funded by the Embassy and Consulate General of the Kingdom of the Netherlands. It was inaugurated in Angri on 11 October 2020 in the presence of the artists, university students, local authorities and the community.

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Evolutionary Time Lines, Hypothesis of an AI+AR–Based Virtual Museum

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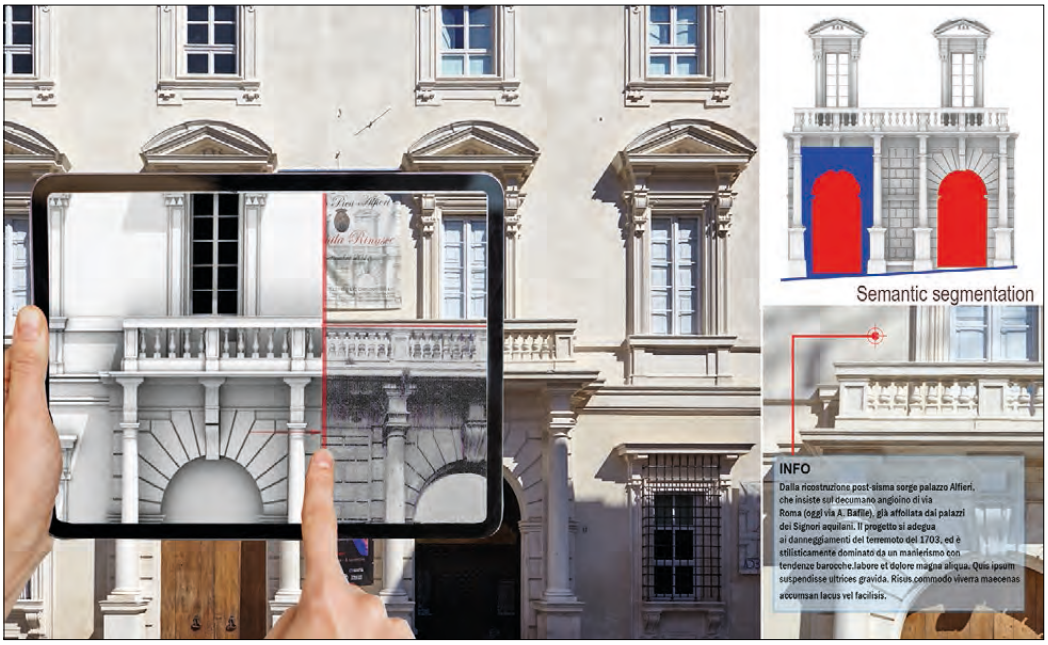
Alessandro Basso

Abstract

The contribution related to the processes of knowledge and enhancement of cultural heritage, based on the potential offered by Artificial Intelligence and Augmented Reality, proposes an analysis of the situation of L'Aquila's buildings ten years after the 2009 earthquake. The research, conducted on the basis of integrated surveys carried out before and after the earthquake, focuses on the application of AR/VR devices through the implementation of AI. The aim is to propose a solution able to promote the use of the historical buildings of L'Aquila, activating at the same time the dynamics of cultural regeneration in the area, through the use of an App that uses AR+AI systems; a tour that can show with immediacy the urban architectural evolution, solving in part the intrinsic difficulties posed by the current situation of precarious visibility and accessibility of some noble buildings, subject to restoration, with the aim of highlighting the evolution of transformations, stylistic and structural changes produced by the different and stratified post–earthquake reconstructions.

Keywords
segmentation, heritage, machine learning, augmented reality, data libraries.



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Introduction

A recurring seismic history hangs over the urban context of L'Aquila, which after each catastrophic event finds the strength to rebuild its buildings, reworking the architecture often derived from the transformations produced by similar disasters in the past. L'Aquila's historical process of formation and change is in fact characterised by phases of renewal that can be traced back in some way to the historical sequence of the seismic events it suffered. The historical phases of the city's evolution lead us to consider the dualism between natural events and anthropic responses as a guiding thread for analysing the events on which the constituent moments of the urban context were formed and regenerated, specifically regarding civil construction. The reading carried out through the filter of the seismic recurrence defines the antecedent to investigate the metamorphosis of L'Aquila's buildings, to understand today's situations considered in the pre– and post–earthquake comparison. Based on historical investigations and surveys that integrate current data with the situation prior to the 2009 earthquake, comparative representations are proposed to allow us to perceptively reconstruct the evolutionary time–lines of some historical Aquila buildings selected as exemplary models. The result is a documentary and informative material that, starting from the original project, makes possible to visualise the subsequent transformations, to appreciate at the same time, scrolling visually on a tablet or smart phone through an App that uses AR and AI systems, the design, the articulation of the facade analysed through semantic models, the current and past images that allow a dynamic knowledge of the artistic and cultural heritage under examination, proposing the monitoring and enhancement of a fragile architectural context, to be preserved and disseminated experimentally already said before (fig. 1).

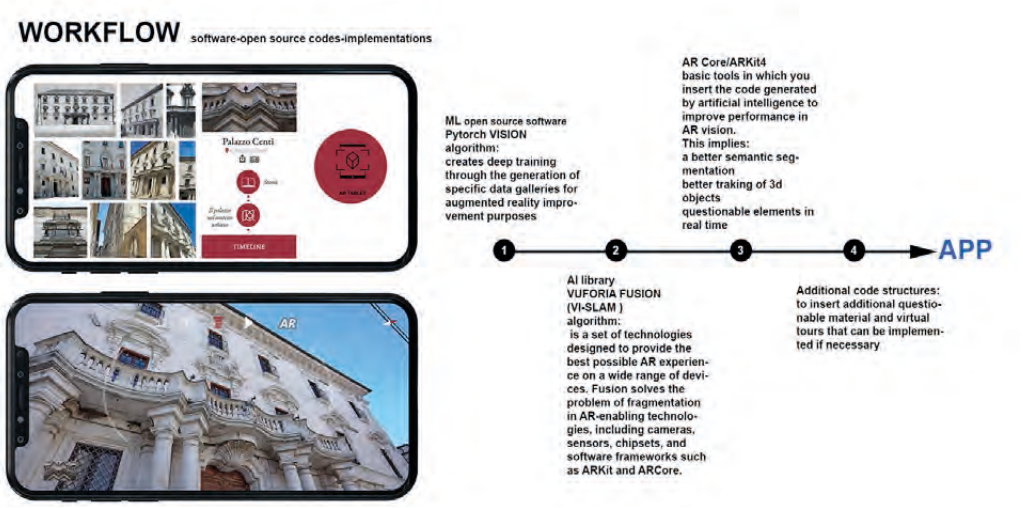

Fig. 1. Development workflow, acquisition and use of data to build a deep learning model with Pytorch Vision, subsequent implementation on ARCore platform for editing the Augmented Reality SDK App.

Machine Learning and AI, the Potential of an Evolving Technology

The paradigms of cybernetic learning are progressively influencing, thanks to the techno–evolution of computing powers and a better accessibility to web networks, predictive models on the acquisition of notions through which man seems to approach 'Data Science' more and more easily, reinforcing the link between human and artificial intelligence in order to achieve innovative approaches to cognitive insights.
The AI, basically applicable when a machine imitates the 'cognitive' functions suitable to structure a logical system to 'learn' and 'find solutions', is nowadays employed in diversified application fields, domotics, intelligent writing, social computing etc., but we can identify its consistent support in the graphic–visual fields of Computer Vision and applicable in disciplines such as Geomatics and Architecture, where multidisciplinary studies, theoretical and practical, are slowly opening towards the analysis and dissemination of Heritage. In spite of these premises, in a purely visual environment it is highly destabilising to think that

a computer can generate 'images', albeit nowadays very unimaginative compared to human creativity, or superimpose almost imperceptibly for example one face on another. Although the inevitable dystopian scenarios conjured up by the idea of cybernetic intelligences coldly replacing human minds instil a recurring doubt, as happens when any new technology is applied in the early stages, for now this suggestion remains a dispute without concrete scientific foundations, tempered by the benefits that artificial intelligence itself seems to offer today, as a support for an artificial logic that can better direct the more emotional human spirit towards concrete solutions. This is the specific application of a class of algorithms that automates the construction of analytical models by offering computers the possibility of learning in complete autonomy without being explicitly programmed. The use of algorithms, which learn through iterative procedures from data input, allows hardware to automatically identify operations to be activated without explicit programming. It is in such an environment, where augmented reality and artificial intelligence can collaborate effectively together, that it is possible to put algorithms together with models consisting of samples that can perform tasks autonomously without the need for complex programming steps.
ML models use self–generated data from which patterns and correlations are learned, while AR is able to merge physical environments with digital content. Augmented Reality and Machine Learning, relatively young technologies that are actually shaping new operational models, thanks to the large amount of available data, now seem to finally bridge the gap between the physical and the virtual world.

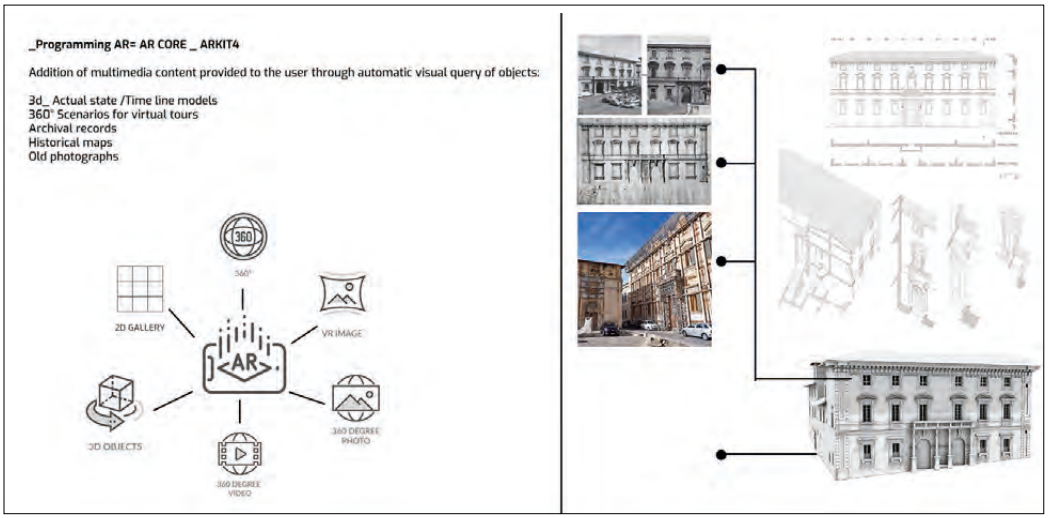

Fig. 2. Programming of ARCore for Android and eventual conversion for ARKIT 4 for the Apple platform. Construction of time–line gallery of the historical buildings of L'Aquila (3D models, photographs, 2D drawings).

Creation of a Prototype for the Historiographic and Stratigraphic Contextualisation of L'Aquila Heritage

The article proposes an application case study, still under development, in which the integration between the two AI+AR technologies is experimented, proposing the use of an App aimed at promoting and enjoying the historical buildings of L'Aquila, activating transversally dynamics of tourist and cultural regeneration in the territory.
Through the use of ARCore systems and the support of PytorchVision system on Faster R–CNN, an interactive tour via smartphone is defined that can show with simplicity and immediacy the architectural–urban evolution of the L'Aquila context. Partially solving the intrinsic difficulties posed by the current situation of precarious visibility and accessibility and providing an accurate visual time line of some noble palaces protagonists of the numerous restorations and superfetations, with the aim of highlighting the evolution of stylistic and structural changes produced by the numerous post–earthquake reconstructions. The involvement of Machine Learning can currently be considered the best tool to speed up the development of Apps for the valorisation of Heritage, as it precedes automated processes to the creation of complex algorithmic codes, aimed at the recognition of ques-

tionable assets and functional to an easier loading in 3D space of explorable digital contents. The results of recent technological research have greatly increased the possibilities and relevance of virtual museology, visibly elevating it from the uses for real museums for which it was once intended. With the introduction of augmented reality, a navigable virtual reproduction is proposed in existing environments through the use of an app for smartphones or tablets, configuring a new concept of diffuse virtual museum, which focuses mainly on the easier usability of a wider and heterogeneous public, together with a better enhancement and promotion of cultural capital that is in part precluded (fig.2).
A virtual experience including three–dimensional reconstructions and interactive insights makes available to the visitor assets that are not accessible or no longer exist, such as works that have been lost or remodelled over time. Moreover, the non–place in which the virtual museum is set up allows the materials of interest to escape from their spatial–temporal constraints, offering a time–line that provides a view of the conditions of the buildings in the various periods of interest, and to be accompanied by multidisciplinary in–depth analyses and thematic–bibliographical links that can integrate the superficial reading, responding in a proactive and coherent manner to the needs of the users concerned. In the case study, these possibilities prove to be particularly valuable in relation to the virtual 'AR' use of buildings affected by disasters or subject to heavy renovation, which are therefore destined to leave no trace of their changes as they do not have a comprehensive, easily accessible and constantly updated digital dossier. In general, visitors who interface with the virtual experience have a better chance of consulting the works, operating in total freedom of observation and enlargement of the selected material, they are free to choose the level of detail and duration of the consultation, and can follow a suggested thematic path or create their own. AR thus constitutes a digital enrichment of physical reality through the superimposition of the former on the latter, providing the user with additional information relating to the surrounding environment. Unlike pure virtual reality, augmented reality uses devices that do not mask physical reality, so as to enable enhanced interaction with it through virtual technologies.
This technology also makes use of more or less sophisticated tools necessary to create a correlation with physical reality, which generally consist of common portable devices such as smartphones and tablets. AR tools do not require total isolation from the surrounding environment, but their use presupposes the user's visual contact with them. This relationship is established thanks to a basic principle of augmented reality, namely that of overlay: the camera integrated in the device frames a given object, the processing system recognises it and activates a new level of communication that overlaps and integrates perfectly with reality, increasing the amount of detailed data in relation to that object. Applying the use of Artificial Intelligence to the editing dynamics of an AR system, the development processes can take several hours of calculation and powerful hardware; despite the time consumed, the results obtained simplify the work of configuring the SDK for mobile devices. For the case study, which is still in the development phase, Pytorch Vision was chosen, an open source resource that, by providing 'training' models based on Artificial Intelligence, allows developers to immediately use image datasets for production, without the need to compile additional complex code to process quality models through a progressive workflow. Both Core ML and TensorFlow Lite models are then automatically generated through pre–compilation, making the subsequent development of apps with ARCore functionality for the Android system more stable, Google technology that allows mobile devices to detect the framed environment, recognise it, and provide interactive AR information. These tools basically offer the possibility to reduce the production time by increasing the quality and consequently the interactivity with the user, amplifying his interest in artefacts related to the enhancement of Cultural Heritage.
The mobile app encompasses in a single instance the diffuse virtual museum experience with wide compatibility at the level of devices and operating systems, always relating in a coherent and recognisable way to the user. The multimedia content consists of galleries of images documenting the historical evolution of the buildings and their changes in time, organised thematically or chronologically, through interactive timelines, in order to adapt to

the needs of the user. These can be supplemented by videos or audio clips that guide the reading of the buildings according to the segmentation inherited from Machine Learning models. The section devoted to digital reproductions also contains technical drawings and 3D models of the buildings, arranged in a space that can be framed in perfect superimposition with the real buildings, which unfortunately are partly inaccessible and covered by scaffolding for safety purposes, useful for a more careful examination of their original globality or for a closer look at the architectural decorations and structural elements that are difficult to observe from street level.

Conclusions

The contribution outlines in an experimental way a methodological workflow developed to monitor and enhance the knowledge and the transformations suffered by the architectural heritage of the buildings of L'Aquila, inextricably linked to the seismicity of the places, to the typical fragility and resilience of the context. The resulting surveys, historical investigations and analytical comparisons have defined the basis for the organisation of the knowledge that, in the integration of AI+AR technologies, has found the formula for optimising and using the data for dissemination purposes in possible new heritage promotion projects.

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Marche in Tavola. Augmented Board Game for Enogastronomic Promotion

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Abstract

This paper aims to illustrate the first experiments deriving from a research project which intends to verify the potential of augmented reality technologies in the field of the valorization of food and wine heritage. In particular, a playful interactive editorial product was prototyped. It was made up of table board and picture cards to be consulted through an augmented reality application based on a web platform. The augmented contents were developed with the intention of showing a possible food pyramid built on the knowledge of the qualities of the typical foods of the Marche region.

Keywords
food and wine, territories, experiences, board game, augmented reality.

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Food as Cultural Heritage

Food and wine heritage represents a fundamental driver that not only enriches tourist offer but also stimulates the economic, social and cultural development of a territory. For this reason, gastronomic tourism requires new strategic, economic and promotional models that encompass different but deeply interrelated areas [Garibaldi 2017].
It is no longer limited exclusively to the purchase of local products or the eating of typical dishes, but the activities also expand to participation in dedicated events or visits to farms, wineries, dairies, etc. A plurality of experiences in which the involvement of senses is qualifying, through which enjoying the cultural heritage of the place in an active and involving way, enriching the value of sharing. Food and wine therefore become a means for the recovery of collective memory and for the characterization of identity.
According to the *Rapporto Sull'innovazione Tecnologica nel Turismo Enogastronomico* [Garibaldi 2020], 62% of Italian tourists would use an application or a website which would lead to the discovery of the typical food and wine of the place, and 52% would like to visit production places which use multimedia technologies to enrich the visiting experience. The author of the Report reiterates that the use of technologically advanced tools and systems such as VR, AR, holograms or multimedia tables facilitate the relationship with the tourist, before, during and after the experience, stimulating a more immersive, engaging and personalized tourist experience.
The research project Food and Wine Heritage in the Marche Region: Digital Storytelling Through Virtual and Augmented Reality [1], conducted by a multidisciplinary team composed of designers, architects, nutrition biologists and computer scientists from the University of Camerino, has set itself the goal of enhancing the Marche region through the use of digital tools and systems that exploit the potential of virtual and augmented reality. The project focuses on new narrative modes, in order to provide insights into the culture of food, and to tell and spread the variety of typical products of the Marche and the territories to which they are linked.
The reconstructions of the historical events of Marche's cuisine and its food traditions reveal interesting relationships between popular and aristocratic, lay and conventual culture, but also between oral tradition and written codifications [Bellesi, Franca & Lucchetti 2010]. These researches gather a vast documentation that testifies how the territory of Marche already between the IX and III centuries B.C. at the time of the Piceni and then in the Roman age, was known for its cultivations and agricultural products, among which wheat, fruits, wine and olives. A great part of this heritage has been handed down through local traditions and in the diffused organic productions, today known in the world for the excellence in wine production or for the primates in the oil and beekeeping fields and for the high quality of restaurants.
However, enogastronomy in Marche represents not only an economic vector, but also an important socio–cultural factor, intimately connected to a complex set of material goods, made of architectural, artistic, environmental and landscape heritage, and immaterial goods represented by culture, identity of places, ways of living and traditions, as well as human resources and entrepreneurial skills [Simonelli & Zurlo 2004].

Research Objectives

The project, therefore, is based on the conviction that through visual design and the use of AR and VR digital technologies, it is possible to achieve the definition of innovative forms of storytelling capable of enhancing the local food and wine heritage and contributing, at the same time, to the revitalization of the cultural richness of the stories, traditions, know–how, beauty, widespread quality and the "genius loci" of the Marche region. In this sense, design constitutes the strategic lever through which to preserve the social and economic–productive characteristics of the territory, in order to avoid creating "synthetic" visit experiences, which can generally transform places into mere tourist attractions.

For these reasons, the research aims in particular to provide technologically innovative tools based on mixed reality systems and technically advanced devices and applications, able to spread the food and wine culture of the Marche region, telling stories and peculiarities of typical products, raw materials and food industry, and how these are combined with the territorial heritage and landscape. In addition, the technological models that are intended to be developed through VR and AR technologies are intended to promote interest in food and environmental education, enhancing not only local products but also the places of origin and production chains typical of the food and wine of the Marche.
Basically it is foreseen the elaboration of a precise narrative strategy based on experiential activities, through the exploration of local itineraries and the discovery of quality food and wine products (when, where and how they are produced and consumed) [2].
In this scenario, in order to guarantee an organic and transversal development of the research project, a working group has been constituted. It includes and interconnects different disciplinary fields. In fact, designers and experts in digital representation were joined by biologists, nutritionists, scholars of the Marche region's diet and computer scientists. In other words, the components together constitute a framework of integrated and complementary competencies, extending from visual design to art history, from videography to landscape surveys, to computer graphics, 3D digital modeling, visual communication, interactive applications, database management, etc.

AR Board Game

Among the activities, those that explore the potential of AR refer to a system composed of a board game to be consulted through the use of an augmented reality application, to be used by smartphone or tablet, able to illustrate in an interactive way a possible "Marche" food pyramid, which aims to promote the knowledge of the qualities of the typical foods of the region.
The board game offers the possibility to know the peculiarities of some local typicalities, through augmented contents, using a series of support cards that, as in an illustrated atlas, accurately describe the products both from a nutritional and a historical–cultural point of view. In essence, it is a system composed of tablet boards and cards to be consulted through the use of smartphones or tablets and an augmented reality app.
This system makes use of a visual lexicon consisting of illustrations that faithfully reproduce ingredients and dishes, more or less known, of the local food and wine, made through a graphic synthesis that privileges a zenithal vision to allow the visualization of the food product in its entirety, and a chromatic system consisting of a palette of homogeneous colors that refers to the original ones. These representations are placed in a graphic field composed of a circular disc, which is meant to suggest the shape of the dish (fig. 1).

Fig. 1. Graphic elaborations related to the maps of food and recipes of the Marche region (elaboration by Livia Barone).

While for the game board representing the geographical profile of the Marche region, neutral chromatic tones were used to obtain evident contrasts with the cards (fig. 2).
The interactions are based on simple dynamics: the cards representing the single typicality, once positioned on the board and framed with your device, will allow the visualization of an animated infographic, which will return information related to the position that the food occupies in the food pyramid, a histogram that illustrates the nutritional values and the territory of origin located within the geographical profile of the Marche region, present in the game board. To complete the experience, a series of special cards dedicated to some typical recipes illustrate in the same way how to 'correct' their position on the pyramid, and consequently the frequency of use, modifying dosages or types of cooking.
The augmented content is composed of the illustrations on the cards and on the boards represented in 2.5 D mode, that is, they are two–dimensional graphics arranged in a three–dimensional space. The platform used is that of Artivive [3] and when the smartphone or tablet will frame the card positioned in the appropriate stall on the board, the cards, depicting the individual typicality, will allow the display of an animated infographic (fig. 3).

Fig. 2. Marche in Tavola, table board.

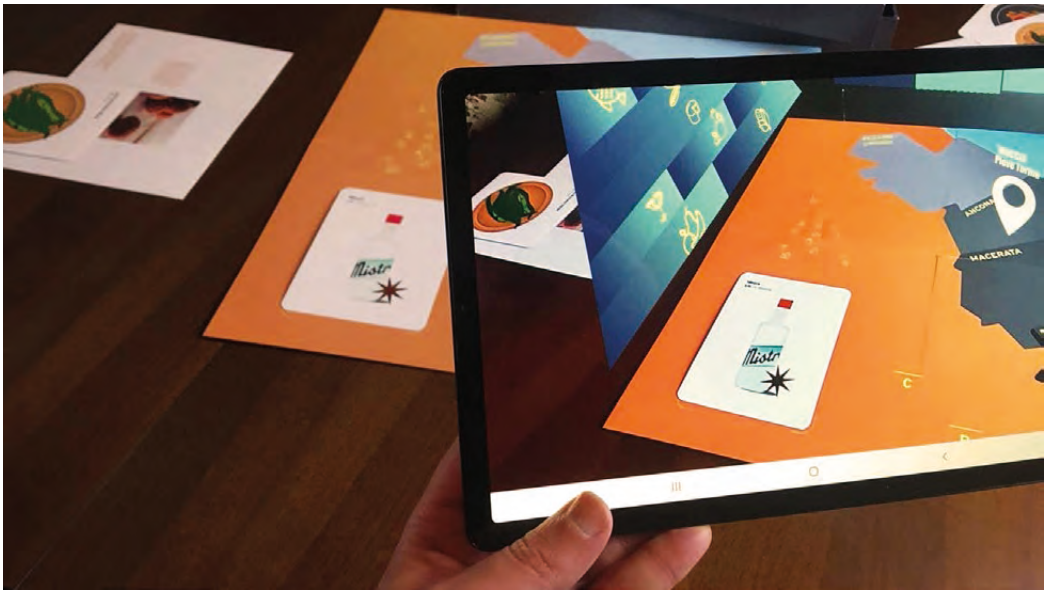

Fig. 3. Augmented information activated by the use of Artivive app

Conclusions

Digital mediation techniques, 3D models, 360 panoramas, dynamic interfaces, redefined spaces and times of learning. Indeed, it is indisputable that today the 'new' media are the protagonists of a 'shift' towards renewed communication models that aim to an extension of the cultural offer in an increasingly rapid and immediate form. The communicative actions and the new forms of representation aim to facilitate understanding, to clarify aspects of complexity, to present concepts in a clearer and more concise manner, to make the information more explicit and useful, while at the same time ensuring a high level of scientific content.
In this framework, the research project explores the potentialities that can emerge from the integration of traditional communication systems made up of paper and editorial artifacts with technologically advanced tools based on mixed reality systems for the valorization of the excellences of the Marche region's food and wine sector. Therefore, the board game project can become useful to understand, on one hand, the levels of interaction between paper and digital artifacts, and on the other hand, to establish the "balance lines of interaction", in order to maximize the general aims of the prototype. In fact, this integration between traditional and digital modes of communication must first of all stimulate the user to delve into topics both of a scientific nature, such as nutritional ones, as well as historical and cultural ones, which are combined with the territory.

Notes

[1] Project funded under the call established by the University of Camerino for the allocation of the 2018 University Fund (FAR). Duration: 24 months (1/2/2019 - 1/2/ 2021).

[2 Among the products analyzed: olive all'ascolana, mela rosa dei Sibillini, miele dei monti azzurri, formaggi di Fossa, salame di Fabriano, pecora sopravvissana, ciuascolo dell'alta marca, crescia fogliata di Fiuminata, torrone di Camerino, salame di fichi marchigiano, verdicchio di Matelica, Vernaccia di Serrapetrona, vino cotto di Loro Piceno, pesca della Valdaso, vincisgrassi, carciofo di Monte Lupone.

[3] The website claims that: "Artivive is the Augmented Reality Platform for Art. This new technology allows artists to create new dimensions of art by linking classical with digital art. The digital layer opens the doors to a whole new world of possibilities". Artivive system is composed by two parts: Artivive App for the visualization and the Creational Tool where everybody can create digital layer to overlap to the reality. https://artivive.com (20 february 2021).

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AR&AI
museum heritage

An Immersive Room Between Scylla and Charybdis

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Abstract

Nello *Scill'e Cariddi* is an immersive and interactive room, in which the marine environment of the Strait of Messina was employed as first experimental scenarios to develop and test the technology. The scenarios reconstruct different settings relating to this unique ecosystem and represent the outcome of a long process of research and systematization of audio visuals available at the Horcynus Orca Foundation. The room, therefore, transforms collections of films, integrating them with the production of specific images, into virtual environments containing structured catalogues and into interactive installations for educational, playful, scientific, and popular use.

Keywords
immersive room, Scylla and Charybdis.

doi.org/10.3280/oa-686.42

The Horcynus Orca Foundation

The Foundation is based in the homonymous interdisciplinary cultural park, managed by the same organization. The Horcynus Orca Park is named after the novel by Stefano D'Arrigo. Its activities involve a complex system of different fields of knowledge (literature, anthropology, marine biology, physics and chaos theory, natural sciences, archaeology, art, earth sciences) that compose the grammar and syntax of this millenary space: the *scill'e cariddi*. The Foundation thus represents an innovative bridge between creative languages, encounters between cultures, scientific research, technological innovation, experimentation with solidarity economies, ethically oriented markets, and dissemination of knowledge. The founding members of the Foundation are the Universities of Reggio Calabria and Messina, the CNR (National Research Council), the Ecosmed Research Centre and some socially and environmentally responsible companies.
The Foundation involves researchers and scholars from different disciplines and has several offices:
– in the monumental complex of Capo Peloro, north of Messina;
– in Scilla and Reggio Calabria;
– on the sea surface of the Strait, on the Kobold platform, the world's first experimental station to produce energy from marine currents, built through a project sponsored by the UN.
Currently the main areas of the Foundation's commitment are three:
– the pole of Mediterranean cultures, with the MACHO Contemporary Art Museum and the event of Mediterranean arts Horcynus Festival;
– the International Centre on Marine and Environmental Sciences and Technologies, which operates under the auspices of the main UN agencies;
– the Centre of scientific dissemination, cultural and educational tourism.

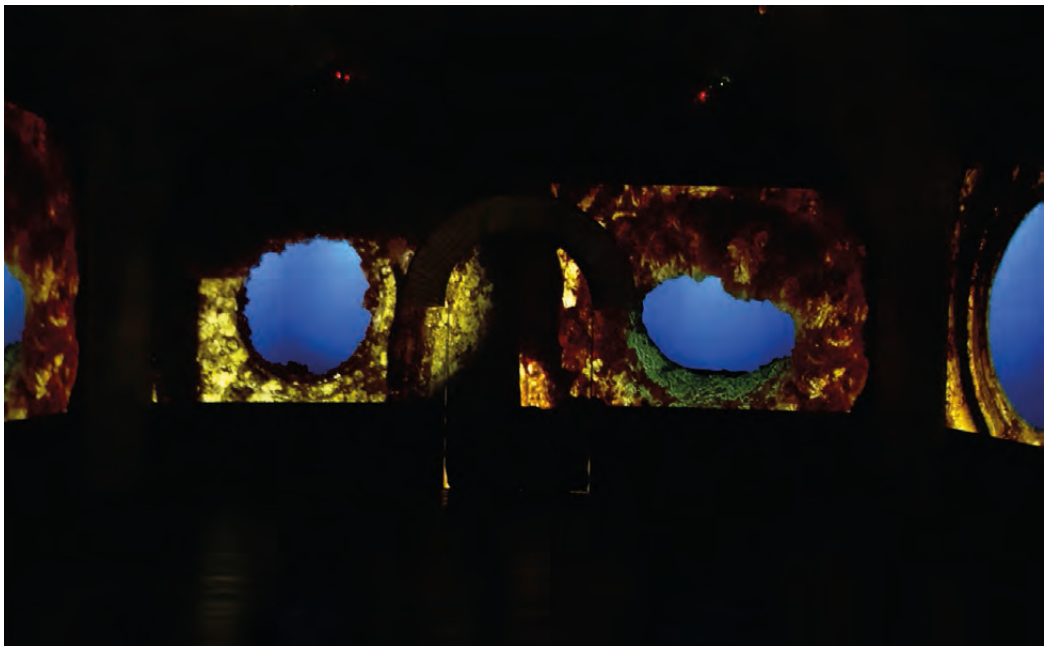

Fig. 1. Panoramic view of the "Oblò" scenario.

The Research Paths and the Architecture of the Immersive Room

The technological development of the room was started as part of the project named *Alfabeti dello scill'e cariddi*, created by the Messina Community Foundation in partnership with the Horcynus Orca Foundation and co–financed by the Italian Ministry of Education, University and Research within the Start Up Call Culture with increased impact. The experimentation elaborates and develops the technology used in the first interactive cinema experiments. The technology used supports different media (photography, video, sound) through interface logics. The system, therefore, inherits the formal grammar of cinema but it also evolves it, because it rejects the form and constraint of the frame; on the contrary, it expands the screen and integrates it with the architectural space.

The project, after a phase of pure research, focused on the construction of a prototype of great suggestion and attractiveness: the interactive immersive room, housed in the hall of the nineteenth–century area (Bourbon fort) of the Monumental Complex of Capo Peloro, a space in direct continuity with the tour of the Horcynus Orca MACHO Contemporary Art Museum.
Multichannel emission systems are installed inside the room; thanks to the use of 3D models and the perfect synchronization of the projections, the immersive environment is smooth and homogeneous. By means of a recognition technology, vertical surfaces are touchscreen; the different ways of contact between the hand and the walls activate interactions in the video and sound effects. In this way, the audience constructs the projection, establishes its timing, and directs its development.
For the realization of the prototype room the following devices/software/systems were installed:
– a cluster of 8 video projectors, each connected to an infrared sensor and to as many computers plus a "control" machine;
– proprietary software intended for the automatic generation of masks to deconstruct the original videos and extrapolate the moving subjects which are then recombined in the recomposition of the immersive scenarios;
– a control system via internal hotspot, connected to the network for on–site control and remote system maintenance.

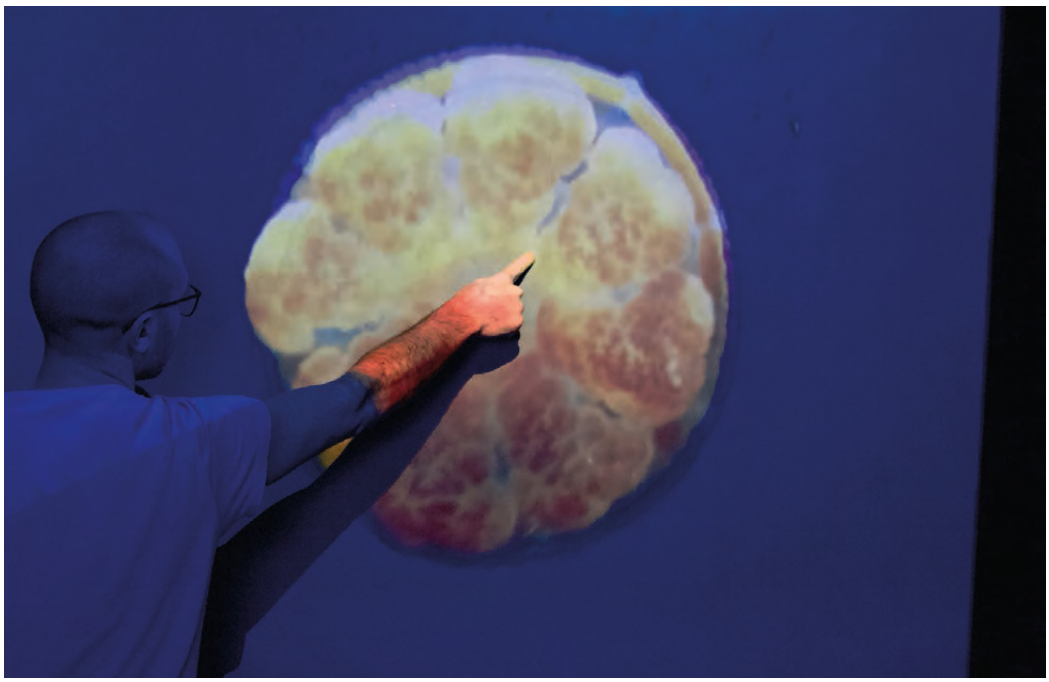

Fig. 2. Detail of the "Meduse" scenario.

The technological structure was designed in relation to the size of the room and the range of action of the sensors, to achieve complete coverage of the projection and interaction on the entire perimeter of the walls. Through video–mapping techniques and the use of specially designed shielding masks on the architectural elements of the room, it was possible to better integrate the video scenic effects and the perception of the historical–monumental value of the building.
The device allows to preset the number of simultaneously detectable touches (in the current setting 16 touches for each of the 8 clusters). The system reads and passes the positions of the interactions to use the data streams in the render engine. The audio, the reading and the process of flows generated by the sensors, the interaction logics, and the multi–channel video graphic production are processed on different hardware but unified by a standard communication protocol (OSC – Open Sound Control protocol) which guarantees synchronization; the workload is managed in a cluster for better system performance.
An advantage of the component system is that the configuration can be quickly changed as required. For example, it is possible to concentrate all the components in the same hardware

or, in output, to compose a cluster of computers by dividing the workload and thus potentially expanding performance indefinitely. Moreover, thanks to its modularity, the developed technology is particularly versatile. The number of clusters that can be integrated into an infrastructure of this type has no predetermined constraints; this makes it possible to vary the arrangement of the individual modules and therefore the shape and overall size of the installation. So, it is possible to vary the number of screens (and video projectors), the number of sensors and computer vision algorithms connected to the system, the number of speakers and audio signals, depending on the type of interactive environment and the place where it is installed.
An *Ambisonic* audio system was installed in the room with the *binaural* technique capable of replicating the functioning of the human auditory system. This technique allows to listen to tracks with an unprecedented quality, virtually bringing the viewer into the sound field in which the recording was made.

Fig. 3. Detail of the "Meduse" scenario.

The Software Architecture of the Immersive Room

The software is structured according to a modular architecture. The individual modules are specialized, i.e. each one has a specific task. Furthermore, each module can communicate with the other modules via the aforementioned Open Sound Control protocol, which allows the implementation of additional modules without modifying the existing ones. The control computer manages the installation by receiving sensor messages at the input and sending the display commands at the output or by performing sound effects and background audio. The modules are distinguished by the following functions:
– Sensors (e.g. Kinect, Realsense);
– Logic;
– Rendering;
– Room management.
The Sensors allow users to interact with the room. For each sensor there is a specific module that manages it and makes it able to communicate with the room logic.
The Logic consists of a program that receives the sensor messages, processes them according to the interaction logics and sends the commands to a rendering engine. The logic of interaction depends on what we have defined as scenarios. Each scenario describes the set of visual and sound events that at a given moment arise from the interaction of users and the mechanisms that regulate them. The Rendering engine is the component that takes care

of visualizing the contents and effects of user interactions. Basically, he is a mere executor of the commands given by the control computer. The overall Management of the room is carried out by a module called "manager", whose task is to switch the entire room on and off, and to start and stop individual programs when necessary. Manager also provides a web interface for changing scenarios and switching the entire room on and off.
The only module that controls the status of the room and the active scenario at a given time is the one that manages the logic. The sensor modules and the rendering module have no knowledge of the room status but are limited to executing commands (rendering module) or sending information regarding user interaction (sensor modules) to the room logic.

The Prototype and Research Developments

The first prototype contains several immersive scenarios of the marine environment of the Strait; they are the result of a path based on research, organization, metadata, and optimization of archive resources.
One of these scenarios reproduces from the inside the walls of a wreck with portholes of various shapes within which it is possible to reproduce films from a collection relating to underwater archaeological sites in Sicily, made available by the Superintendence of the Sea of the Sicilian Region. Other scenarios allow the public to discover the environments and marine species of the sea surface and the abysses of the Strait; thanks to the interaction, each touch makes sea creatures appear alive and in motion, selecting them randomly from a database.
Nello Scill'e Cariddi is a prototype dedicated to underwater scenarios, but the project makes it possible to stage, at low cost, settings relating to different themes: figurative art, virtual scenography for performing arts, archaeology; scientific dissemination projects, sensory itineraries for disabled people and, more generally, educational paths. The Horcynus Orca Foundation has already created additional collections of interactive immersive environments and therefore the archive is constantly being implemented.
The first interactive art installations have already been created, including Ultrathinking by the Iraqi artist of Kadir Fadel and *La Habana Sobre Ruedas* by the Cuban collective composed of Claudia Hechavarria Segura, Juan Alberto Matamoros Nues, Elvys Ariel Urra Moreno; a first experimentation of ensemble music in which it is possible to activate with infinite combinations up to 32 instruments of a virtual orchestra curated by Luigi Polimeni; the first experiments of interactive virtual scenography through the collaboration with *Mana Chuma Teatro*. Some virtual scenarios on matter and the cosmos are at an advanced design stage, in collaboration with the National Institute of Nuclear Physics; titles suitable for children with particular types of autism spectrum disorder, in collaboration with the CNR–IRIB (Institute for Research and Biomedical Innovation) of Messina; a historical–archival project for the reconstruction and investigation of the scene of the Portella della Ginestra massacre.

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New Cultural Interfaces on the Gallerie dell'Accademia in Venice

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Abstract

In the digital age, museums have seen a significant expansion of the spaces and tools for disseminating knowledge. Gallerie dell'Accademia had commissioned a permanent and multimedia video that summarized the results of the interdisciplinary research developed within Visualizing Venice – S. Maria della Carità, S. Agnese, and the Gesuati, three insulae make one – that told about the history of the urban and architectural transformations of the insula. Since it is not a totally immersive installation, some years later Gallerie asked to make some changes to the previous animation to allow a greater interactivity between user and observed data. In order to keep the visitor's attention threshold high and active, different sections of short duration have been introduced, which can be interrogated and activated by sensors, while a Sound Shower system facilitates the understanding of the multimedia story through the listening of a narrator's voice.

Keywords
virtual reality, digital model, database, interaction, immersivity.

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Venice in Motion: the Site of the Gallerie dell'Accademia Between New Media and History

The idea of Venice as a city constantly in motion has been recognized for some time now, so much so that it has become a truly significant feature of its own image. Movement does not only concern individuals, goods, and objects, but also its urban and architectural space. This pertains to the transformation of buildings and the relationship between land and water, but also – and equally importantly – it involves the functional use of space, the articulation of collective facilities, and the city's appearance. To these extents, the area of the Gallerie dell'Accademia represents an exemplary case study of inquiry. Located on the southern margin of Venice, in a transitional space stretching between the Grand Canal and the Giudecca Canal, the site consists of three insulae named for the ancient religious complexes that once moulded its space: Sant'Agnese, the Gesuati, and Santa Maria della Carità. The latter, which consisted of the church, the adjacent monastery of the Lateran Congregation of the Canons Regular of Saint Augustine, and the Scuola Grande, was converted at the beginning of the nineteenth century to accommodate the Academy of Fine Arts and later, in 1817, the Gallerie dell'Accademia [Codello 2017]. The history of these institutions and pertinent buildings has been widely investigated by art and architectural historians who devoted particular attention to Andrea Palladio's design for the renovation of the monastery of the Carità [Modesti 2005, 2005b]. However, the long–term history of today's site of the Gallerie dell'Accademia and its interwoven relationships with its surrounding urban fabric have remained largely unstudied, in part because of the difficulty to show the public how the museum was inserted into existing spaces and in what way these places have changed over time [Svalduz 2017].

If looking today from above, the area emerges as a compact and uniform site, but actually its topography is the result of a process of urban and architectural stratifications that spans a thousand–year history. Until the beginning of the nineteenth century, the settlement was designed by an articulate system of waterways, which included two straight canals – the Rio della Carità and Rio di Sant'Agnese – crossing the site longitudinally and flanking both sides of the Lateran Canons' complex. As part of the process of modernization undertaken in the aftermath of Napoleonic rule, the two watercourses were filled in, while the erection of a new bridge over the Grand Canal definitely brought the entire area out of isolation by ensuring a rapid pedestrian link to the rest of the city [Galeazzo 2018] [1].

These changes profoundly altered the urban settlement's configuration, as well as the visual perception of the ancient buildings, especially of those belonging to the Lateran monastery. What had previously been a sort of fortress surrounded by water gradually became integrated into the city [di Lenardo 2013]. In addition, the conversion of religious buildings into secular places eventually led to an invasive campaign of renovation of the ancient structures, which were stripped of their decorations to avoid any visual–mental connection to the former ecclesiastical complex.

The emerging dialogue between new media and traditional historical research offered the multidisciplinary team the option of experimenting an innovative approach to visualizing and communicating these historical changes. The video 'The History of a Site and its Transformations: From Carità to the Gallerie dell'Accademia' was created to exploit the affordances of emerging technologies as a powerful tool for giving visitors a simplified and comprehensive understanding of the area's elaborate changes over the centuries. The project had two overlapping objectives: to shed light on the urban and architectural transformations of the urban site while focusing on the impact these modifications had in the land – and water – based Venetian traffic systems and to visually represent the relationship between the previous structures and the present spaces of the museum to help visitors understand the origins of the complex. The philological reconstruction of this large section of the city was based on the collection of a broad scope of historical sources and identification of a series of significant chronological phases that represent many temporal snapshots in the history of the insula's transformation. These span over five centuries and help visualize the tight bond between space and architecture. Beginning with the renowned bird's–eye view of Venice by Jacopo de' Barbari (1500), the video then reconstructs the eighteenth–century shape of the

newly–built church of the Gesuati as well as the spatial organization of the monastery of the Carità through both cartographic and iconographic sources. These encompass the first city's map of Venice by Ludovico Ughi (1729), several detailed drawings executed by local magistrates, a sequence of Canaletto's paintings, as well as some precious surveys elaborated by the proto Pietro Angelo Fossati immediately after the suppression of the Augustinian monastery in 1793. Napoleonic (1808-1811), Austrian (1838-1842) and Austro–Italian (1867-1913) cadastral maps were instead crucial for mapping nineteenth–century transformations of the waterway and pedestrian system [Galeazzo, Pedron 2014].
While the goal of the video is primarily didactic and informative, showing the transformation of the area from the early Renaissance to the twentieth century, it also allows users to physically experience the transformation of water–courses into pedestrian paths through a virtual trip along the now filled–in canals, it brings also a contextualized understanding of how an amphibious city like Venice was subjected to a gradual process of land reclamation.

Digital Representation of Architectural and Urban Changes Overtime

Cinema and photography embodied the main cultural interfaces of the 20th century, tools through which it was possible to describe the movement. With the advent of digital representation, virtual reality has 'stolen the scene' from previous forms of communication. According with other devices, the monitor has become more and more important since it constitutes the limit of the virtual vision, the tool with which the user/observer must interface an illusory space through a sort of virtual window. It is a threshold from which to experience a mosaic of information perceived from multiple points of view referring to many different reading planes. The main novelty of the man–computer–culture interface lies in the revolutionary way in which machines present data and allow to interact with them [Manovich 2009].
The installation created for the Gallerie dell'Accademia involves the projection of a digital movie on a videowall [2]. The first frames of this movie serve to contextualize the three ancient insulae as they were in the 16th century urban fabric. The digital reconstruction was carried out through a process backwards in time starting from the actual state of the insula. The narrative structure and the storyboard of the installation follow instead a linear exposition of the events, which allows a reading without interruptions and reversals the chronological order of the events. The story retraces the historical phases starting from 1500 up today. The large amounts of documents, historical data, literary and graphic sources constitute the documentary substrate on which this work is based.
The starting point of the modeling phase is the state of the insula as we did in 2015, when the original movie was created. Maps, engravings, drawings, surveys, chronicles, photographs and publications were added to the virtual platform.
The next step concerns the identification of the historical moments in which the most significant transformations of the urban fabric occurred, identifying six main historical phases summarized here and appropriately arranged with historians, which provided the starting dates: 1500, 1729, 1794, 1811, 1842, 1906 up to 2015. Where the information on individual buildings was not sufficiently clear and comprehensive to develop a detailed model, we preferred to omit its representation, opting for a volumetric abstraction of the building rather than originating an arbitrary interpretation, not very rigorous from a scientific point of view. In the movie, the concept of time is explicitly expressed through a timeline, always visible on the screen, which attests the chronological sequence of events throughout the centuries considered. The timeline, arranged vertically, determines the page layout. Moving forward chronologically, it ideally cuts the screen into two parts (one twice wider than the other), following the horizontal division defined by the width of the monitors that make up the video wall. The size of the monitors and their mutual approach define the standard layout, the guidelines of an ideal and a modular grid, that help us to insert the documents. On the right, the visitor can see the plan of the insula, a static image accompanied by some tags that highlight the main urban and architectural changes occurred over time; on the left, instead, all the documents appear in a fading succession (fig. 2). This documents are the data

that allowed us to model the urban situation in a precise historical phase. This roundup of static images concludes with a render of the digital model at the specific year. To interrupt the static images of the movie we set a virtual tour around the insula, as it was in 1794, along the canals now filled–in. The animation is introduced by a plan that shows the path of the camera around the insula della Carità during the tour. Suddenly the timeline, moving to the right side, gives the space to a full–screen movie: a representation within the representation, in which the viewer is involved in the perception of urban spaces from a today unusual and no longer available perspective that coincides with that of a visitor who is navigating the canals using a gondola, exactly as a citizen of the past centuries. The camera, simulating the eye of the observer, moves through two canals – the Carità and Sant'Agnese – in a position slightly above the water level, stabilizing a perspective horizon that coincides with a line just a bit over the walking surface. The movement of the camera inside the virtual environments is necessary to overlap a document directly on the 3D model to explain the reconstruction of some elevations of the buildings that face the canals, of which we have a precise document, like the precious surveys made by the engineer Pietro Angelo Fossati in 1793. These drawings can be rightly positioned only in a virtual 3DF model that takes into account the movement of an observer floating on a boat. Following the idea of updating our first installation to new technologies, the same team of scholars has recently proposed to the museum an integration of the display with other in–depth historical studies to offer visitors a broader knowledge of the site. Users will be invited to choose between different lightening chapters, which are diversified basing on analysis, topic, and disciplinary approaches [3].

Conclusions

Recently the Gallerie dell'Accademia has asked for some changes to the previous animation, the aim was to improve the interactivity between user and data. At the moment the *ad hoc* app, is a loop animation. But in the next future using an interactive menu by a gesture system it will be possible to chose which kind of documents it is going to visualize: digital videos, images or texts. The app keeps in connection the input and output devices linked to the PC in order to allow to check how to visualize documents.
The Kinect's cameras allow to the user to interact trough e gesture system using only movements by hands and arms, without using fisical devices that control the movements. The open hand pointed to the monitor will allow to activate a main menu, moving on the differente voices and choseeing the preferit section. In the same waythe user will come back to the principal animation. Finally the sound shower system will allow e directional and localized diffusion of audio track of videos, in order to obtain a more immersive experience. This tool conveys to the sound in a limited area of the room not to disturb the visitors in adjacent exhibition spaces (fig. 3).

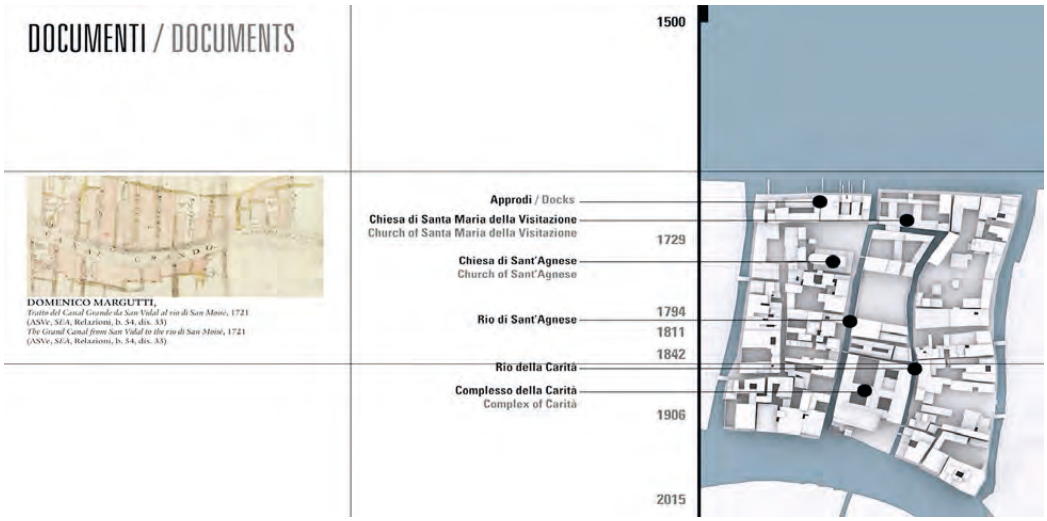

Fig. 1. Layout of frames of digital video.

Fig. 2. Devices of the new interactive installation.

The introduction of an interactive action makes between visitor and installation made the reading and the learning of the urban and architectural story of the of the insula della Carità more involving. Operations of this kind can be considered as alternative tools, available to museums, for a transversal dissemination of knowledge, but this implies that the role of the representation of architecture and the city is called to respond to new challenges [4].

Notes

[1] The Carità and Sant'Agnese canals were filled in 1817 and 1863 respectively. In 1854, the English engineer Alfred Henry Neville built a suspended iron bridge, which was replaced in 1933 by a supposedly 'temporary' wooden bridge by Eugenio Miozzi.

[2] Each liquid crystal monitor is 46' in 16:9. The assembly of the devices provides for a 3x3 arrangement, i.e. three monitors along the horizontal direction and three along the vertical one set on one of the longitudinal walls of room 4, occupying a total area of 5.238 square meter. The realization of the video assembly was achieved thanks to funding and sponsorship from Samsung Electronics Italia s.p.a. and Ventian Heritage, which supplied the monitors necessary for the projection of the images.

[3] These narratives will include: the investigation of the insula dell'Accademia as an area between various ecclesiastical communities; the digital reconstruction of Andrea Palladio's design for the monastery of Carità and its relation with the realized buildings of the museum; and the nineteenth– and twentieth–century architectural transformations of both the exterior and interior spaces of the Lateran Canons' complex, made to house the Academy of Fine Arts and the Gallerie dell'Accademia. A specific chapter will also be devoted to the campo (square) that faces the Grand Canal and its ancient functions of cemetery, docks for boats, place of humanistic encounters, space for ceremonies and events.

[4] Venice in Motion: The Site of the Gallerie dell'Accademia between New Media and History was written by L. Galeazzo and E. Svalduz; Digital representationo of architectural and urban changes overtime was written by I. Friso and C. Monteleone; Conclusion was written by F. Borella.

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Wood Inlays and AR: Considerations Regarding Perspective

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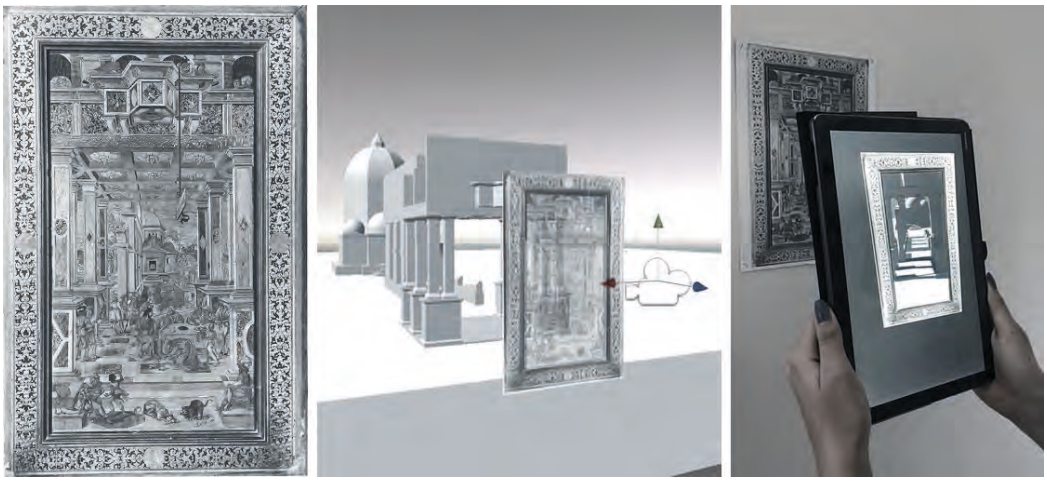
Abstract

The contribution reflects on the options provided by recent Augmented Reality (AR) applications to the knowledge and enhancement of a nationally and internationally renowned cultural asset: perspective wood inlays.
The methodology envisages two closely–connected stages initially involving perspective decoding and ensuing reconstruction of the illusory model, followed by the creation of a set–up for the AR pursuant to the digitalization of the three–dimensional model.
In AR, perspective is the ideal tool to virtually experience the space represented in the decoration; at the same time it provides the most suitable solutions required to optimise the AR project.

Keywords
wood inlays, perspective, augmented reality, immersivity, dynamic perception.



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Introduction

This contribution [1] focuses in particular on wood inlays that primarily use a perspective approach to create the image, i.e., early Renaissance and sixteenth–century intarsia that exploit an elegant perspective technique to produce wood decorations.
There have been many recent examples of AR/VR applications used in environments embellished by wood inlay decorations. In particular the ones in Federico da Monfeltro's studiolo in Gubbio and Urbino which were developed to virtually recreate the rooms' artistic quality [2]. Said studies focused more on communicating the cultural asset rather than speculating on the perspective–geometry used to create the illusory space, achieved due to the sfondamento of the plane of the wooden cladding.
This contribution will instead concentrate on the common projective origin of the two representative models: on the one hand the perspective model, on the other the digital model behind the AR experience that can be visualised on an ad hoc display.
Our goal regarding the projective and perspective features linking the perspective sfondato with its AR version is to verify whether these features are the key elements required to successfully recreate the spatial complexity of this particular artistic genre.
To test the methodology we selected an intarsia made by Brother Damiano Zambelli around the year 1530 and inserted in the backrest of the choir stalls in the presbytery of the Basilica of San Domenico in Bologna (opening image, left). When an onlooker looks at this intarsia, or at any other perspective inlays, he perceives an illusory space beyond the wooden frame, in this case a quadrangular hall with a Lombard–style coffered ceiling resting on two rows of three pilasters, the remains of a building in the middle ground, and a temple in the background [3].

Considerations Regarding Perspective and AR

Two features betray the similarities between perspective and AR: one involves the fundamental elements of projection, the other concerns the elements participating in the creation of the perceptive experience of amplifying space.
The first step is to verify parallelism between the centre of projection, the picture plane, and the model to be represented as crucial elements of the perspective, and, respectively, the virtual camera, the target, and the three–dimensional digital content in the AR.
The effect of amplifying real space is created by skillfully using the perspective technique; it is effectively similar to the AR experience after accurate correlation is established between perspective construction and the design of the virtual fruition application.
The illusory space conjured up in the wooden intarsia is possible thanks to the observer's sensitivity and visual and artistic knowledge, while the perceptive functioning of the AR is generated by superimposing suitably designed digital contents on real space; these contents are activated by establishing a specific target.
In this respect, we must carefully consider the element to be used as a target to recognise the virtual model that we can presume to be either the inlay itself or an orthorectified image of the inlay itself.
As we all know, perspective theory allows for endless positions of the model to be represented compared to the picture plane (in fact the object can be between the centre of projection and the plane, beyond the plane, or even astride the plane). Nevertheless,

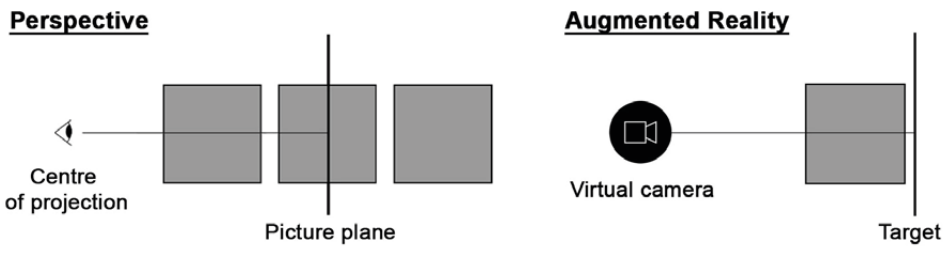

Fig. 1. Schematic drawing reflecting on the possible relationship between objects and the picture plane in perspective construction (left) and the model appearing in front of the target in AR applications (right).

when we look at a wooden intarsia the perceptive effect sought after and recreated by the artist is to place this space 'beyond' the physical limit of real space, i.e., beyond the inlay, which, in turn, can be equated to the perspective picture plane (fig. 1). Instead in AR, after activating the application the digital model appears in front of the target (fig. 2). In perspective intarsia applications this disorients the onlooker who no longer easily perceives the continuity between the two–dimensional perspective image and the reconstructed space in the digital model (fig. 2).
To restore the immersive effect a solution could come from the nature itself of the wood inlays and their dimensional characteristics. In fact, inlays are primarily framed by a scansion of the wood surface so that the dimensions of each sfondato corresponds to that of an opening (door or window). The space imagined beyond the wooden plane appears to be divided into as many sfondamenti as the number of perspective panels, usually bordered by a compositional element that acts as a frame for the intarsia. This allows us to theorise that the latter is the element tasked with mediating the shift from the perspective image to its digital reconstruction by inserting, in the model, an element present in the target.

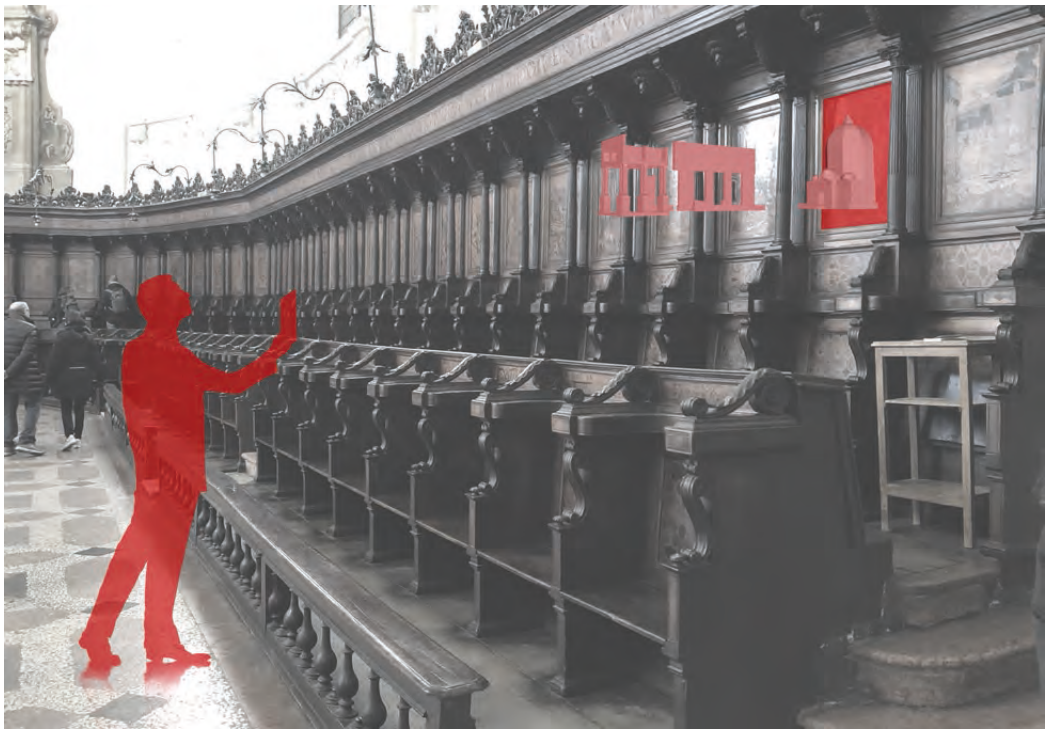

Fig. 2. Concept view, inside the choir of the basilica of San Domenico in Bologna. The image shows user perception of the application of AR in the case the necessary changes are not made to obtain the perspective *sfondamento*.

Let's now focus on the case study, i.e., the inlay in the choir stall in the Basilica of San Domenico. We have outlined the aforementioned considerations because in AR the digital model is visualised in front of the target; the chosen target is in fact the intarsia itself, while the one perceived by the onlooker is a model that does not 'pierce' the wooden plane, but instead exits it and is projected forward into real space, nullifying the illusory effect of spatial depth beyond the inlay. To eliminate this undesired effect, a decision was taken to make part of the target (i.e., the frame around the scene) an element of the model produced for the AR application. The outcome was a virtual frame perfectly superimposed on the physical target in front of said urban scene.
Solving the issue of the target is the first step in achieving successful restitution of illusory space. Another inconvenience is the presence of elements in real space that conflict and are visualised with the ones in the digital model – possibly including the target itself.
Once again, the solution was found in the common projective origin of the wooden sfondato and AR application. In this case, the applied strategies were instigated by the perspective used in theatrical stage sets and photography.

A box–like environment inspired by photographic box sets was created to isolate the urban scene beyond the frame and stop the real environment from being considered as a background. This involved creating a delimited digital space characterised by neutral textured materials in which the rounded corners did not reveal the change in position of each plane. Inserting the digital model in this box eliminates the presence of real space elements that are thus inserted in virtual space, helping to reinforce the perceived effectiveness of the AR experience (fig. 3, left).
Nevertheless, the digital model and the box set in which it is inserted are both a certain size and can be visualised as an insertion in real space; this is the third element that helps to weaken the illusory sfondato of the wooden surface. Once again the solution lies in the perspective–scenographic origin of the two models, the perspective model of the intarsia, and the illusory AR model; it is reminiscent of the proscenium arch in many theatres or mobile stage sets. When a foreground frames the scene it amplifies the perceptive effect of depth; this has been common knowledge ever since antiquity, especially in the theatrical world; the 'trick' is used both in the field of perspective and that of photography.
In a theatre, the proscenium arch in the foreground plays a dual role: apart from framing the stage and interrupting continuity with real space, it makes the space of the stage less immediately 'measurable' and isolates the parts of the scenery and machinery that spectators should not see.

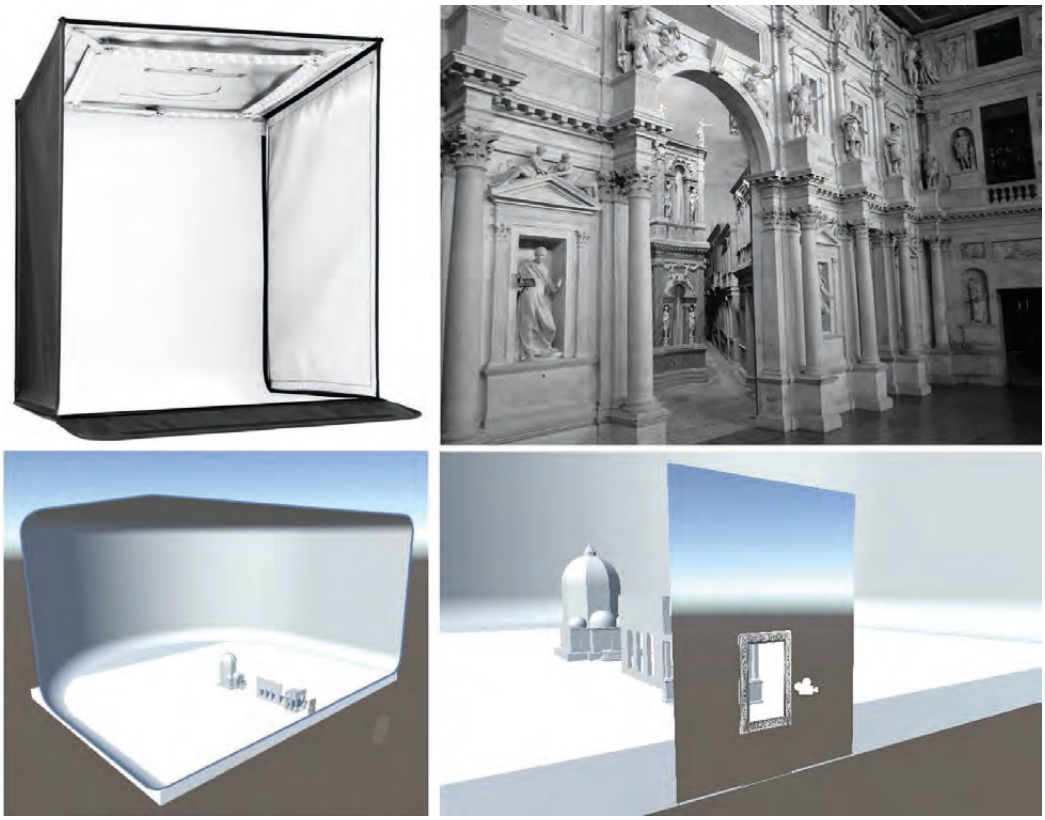

Fig. 3. Box set (top left) and proscenium arch (top right) applied to the virtual model (bottom).

Placing this element in the model elaborated for the AR application involves inserting a sort of screen and assigning it certain characteristics and materials so that it isolates the model, but cannot be seen when the application is used. In our case study, for example, this additional insertion of a screen in the foreground, was appropriately cut to show only the part of the sfondamento that the onlooker was allowed to see (fig. 3, right).
The presence of an element of the target in the digital model, coupled with the creation of the box set and insertion of a screen, facilitated seamless exploration of the space of the AR with fruition of the real space where the inlay is situated; it also facilitated a comparison between the digital model and the perspective image.

Conclusions

The use of AR in perspective applications and, in particular, in wood inlays, raises several questions; a suitable solution lies in the realisation that the two systems share a projective origin. Bearing this in mind, and focusing on the world of theatrical stage sets and photographic technique – two technical–artistic mediums with the same roots and same scientific evolution – provides us with important knowledge and helps solving some of these issues.
Obviously this contribution ignores other aspects that are nevertheless crucial and should be considered in a much broader study.
In fact, it will be necessary to tackle the question of the implementation of materials, lights and texture in the model for the AR application; these elements can be identified by analysing the inlays themselves, but will have to be correctly managed.
Another aspect not tackled here, although inevitable, is the relationship between the position of the observer of the perspective (presumed to be stationary in the environment) and the kinetic nature of AR exploration.
Nevertheless, once again, in the case of perspective inlays, AR proves to be the right tool to enrich the experience of all those who wish to enjoy cultural heritage thanks to an approach which, by increasing perceptive options, also includes scientific contents – all too often relegated to the back burner.

Notes

[1] Although all the authors participated in the whole research, the study of the wooden intarsia, their perspective construction and specific case study was performed by M. Fasolo; the part regarding the relationships between perspective and AR was performed by L. Carlevaris; in–depth operational studies and the creation of the models and contents of the AR application were performed by F. Camagni. The conclusions are part of the joint research project.

[2] Regarding the *studiolo* in Urbino, see: Roberto Mantovani, <https://www.youtube.com/watch?v=kShbXHYI7G0> (consulted on 11th February 2021); the project *Lo studiolo di Gubbio: tour virtuale e ipotesi ricostruttive di un microcosmo umanistico*; Paolo Clini, *Lo Studiolo di Federico da Montefeltro. Fruizione del Cultural Heritage attraverso nuove tecnologie di realtà immersiva*: <https://www.facebook.com/watch/?v=690533685114053> (consulted on 11th February 2021). Regarding the decorations in the *studiolo* in Gubbio, currently housed in the Metropolitan Museum in New York, <https://www.youtube.com/watch?v=8MTgRlEuHBg> (consulted on 11th February 2021).

[3] Cfr. Alce 2002.

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Augmented Reality and Museum Exhibition. The Case of the Tribuna of Palazzo Grimani in Venice

Giuseppe D'Acunto

Abstract

The purpose of this research was the exploration of the potential of the combined use of augmented reality and rapid propotyping for the enhancement of Cultural Property. This specific study explored how these innovative methodologies can be effective in the creation of museum exhibitions which are not only able to show the contents of the exhibition itself in an original and captivating way, but also to recover the memory of a place by reconstructing the original position of the surroundings strictly connected to the sculptures they have been deprived of over the centuries.
It is the case of the Tribuna of Palazzo Grimani in Venice and of the statues that used to adorn its walls. The majority of these statues are now preserved in the National Archaeological Museum of Venice in an attempt to reconstruct their original appearance and disposition, and to offer the public a wholesome vision through augmented reality.

Keywords
augmented reality, digital models, digital survey, museum exhibitions.

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Among the various challenges that those who deal with exhibitions have to face every day, one of the most stimulating and insidious at the same time is the representation of the intangible value of the exhibited goods. Representing the intangible stratification of meanings and contents of a fragment of heritage – it being archaeological, architectural, cultural, or of any other nature – is an undertaking not to be taken for granted and is characterised by the need to maintain a continuous equilibrium between scientific rigor and narrative effectiveness. From this point of view, the evolution of the narrative codes and the increasingly widespread and rooted presence of the media have played a fundamental role in, on one hand, enormously enriching the range of solutions available to designers and curators, and, on the other hand, making this field significantly more complicated. Therefore, it is not surprising that, with usable patterns increasingly more shaped by the indissoluble influence of technology and its complicated rules – immediacy, accessibility, superabundance, experientiality – the contamination of the traditional codes with innovative languages and other narrative solutions has become a trend that is as natural as unavoidable and necessary. This is even more evident when museums are concerned, since the quality of an exhibition is determined, among other factors, also by the ability to show the intangible value of the exhibited goods in a tangible, effective and, most importantly, universal way.
The reconstruction of the position of the statues of the Tribuna of Palazzo Grimani in Venice exegetically explained in this essay is an experimentation of a museum exhibition in one of the most iconic places of Venice structured and organised according to the possibilities offered by augmented reality. The purpose is to show the original aspect of this place that has been lost over time.

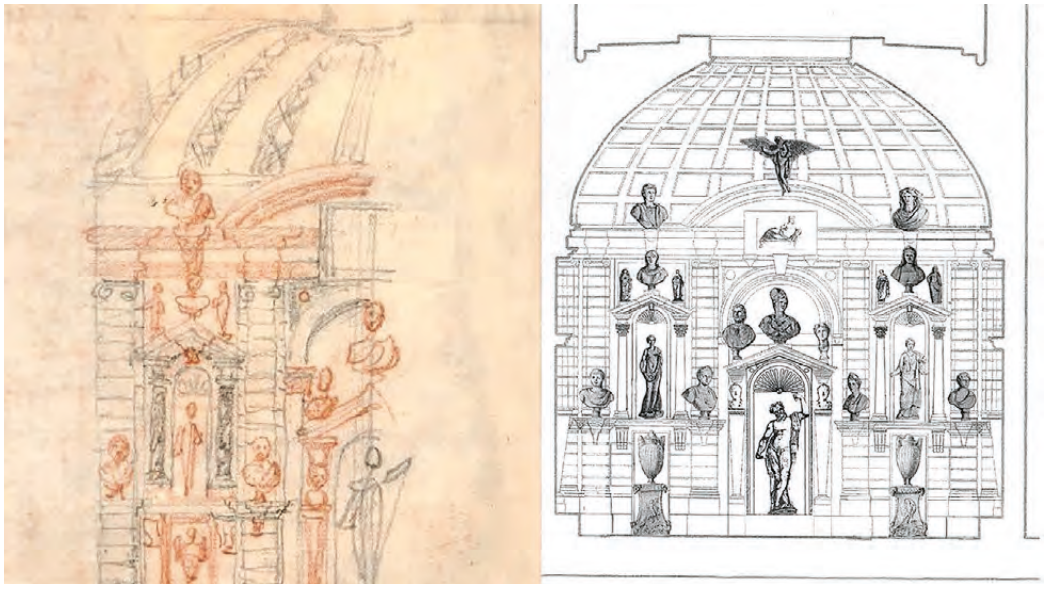

Fig. 1. (left) Reconstruction of a portion of the Tribuna by Federico Zuccari, 1582. British Museum, London. (right) Reconstruction of the wall facing the entrance. Favaretto I., De Paoli M. 2010.

The Tribuna was built in the second half of the 16th century at the will of Giovanni Grimani, patriarch of Aquileia. It was clearly inspired by the Pantheon and illuminated from the above by an opening in the centre of the roof vault. It contained an entire collection of statues in a very scenographic way due to an articulated system of lights and a refined system of niches and shelves. Even though there is no written evidence, it seems that the critics have endorsed the theory according to which Francesco Sansovino curated the architectural project of the Tribuna, as reported for the first time in a small anonymous guide of the end of the 18th century called *Pitture e scolture nel palazzo di casa Grimani a Santa Maria Formosa*. This space was attributed the name '*Tribuna*' only in the descriptions of the guides between the 18th and 19th centuries [1], but it was originally known as Antiquarium (studio of antiquities), as reported by Francesco Sansovino in his famous book *'Venetia città nobilissima et singolare'* dated 1581 [2]. In another passage of this book, there is a detailed narration of the

visit of Henry III, king of France, and Alfonso II, duke of Ferrara, to patriarch Grimani in the autumn of 1574. Sansovino described the amazement of the two illustrious guests towards the wonders that the Venetian Palace and, in particular, the Tribuna – where the entire collection of statues was displayed – offered.
Thus, it can be assumed that the Tribuna was largerly complete between the 60s and 70s of the 16th century, and the fame of its wonders had already spread throughout Europe, even though this setting, as originally organised, survived only less than thirty years. While still alive, Grimani bequeathed the entire collection of statues to the Serenissima Republic of Venice in 1586, with the intention to create a Public Statuary situated in the anteroom of the Marciana Library. According to the chronicles of the time, the transfer of the statues to the Statuary of the Serenissima started in 1593 (the same year in which Grimani died) and ended in 1596. During this operation, the first inventory of the entire collection, known as the Pellegrini Inventory [3], was compiled. This document is still of great importance in the attempt to recreate the historical issues of the Tribuna and it is one of the few written descriptions of the entire collection of statues in the room before their transfer to the Public Statuary. Another fundamental document that gives us the precise idea of the original aspect of the Tribuna in those years is the description dated 1593 that can be found in *'Storia del Friuli'* by Germano de'Vecchi.

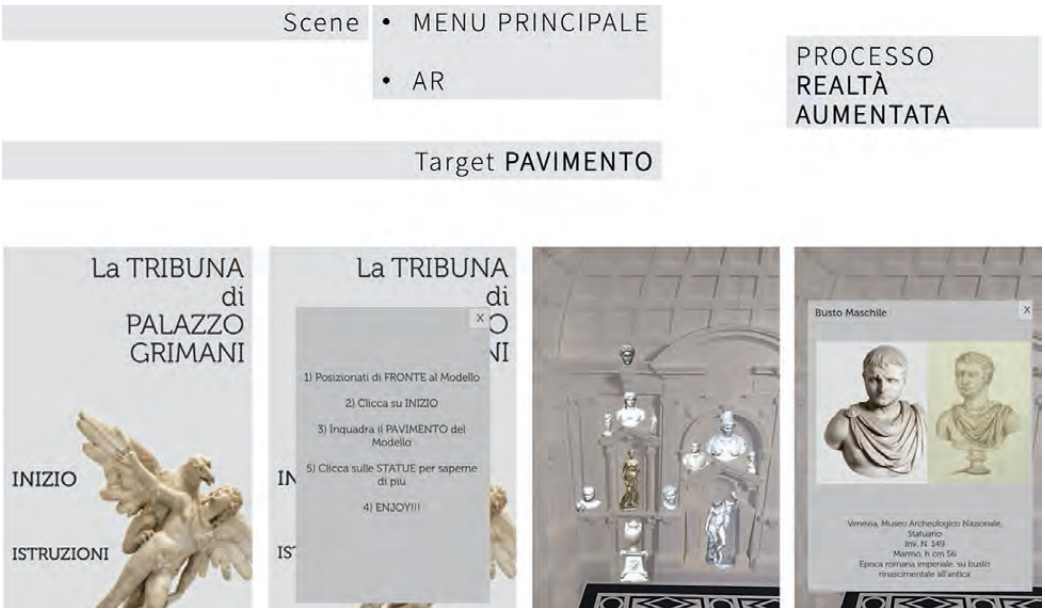

Fig. 2. The screen of the application in augmented reality with an example of multimedia card with the in–depth interactive contents for each individual statue. Digital elaboration by Valeria Sambucini.

As already mentioned before, the descriptions and positions of each statue as reported in the two inventories are incomplete and often approximate and they lack a graphic apparatus able to convey the exhibition in its original aspect with the correspondent disposition of the sculptures in the Tribuna.
Among the various studies about the Tribuna of Palazzo Grimani and its collection of statues, one that is worth to remember is that of the scholar Marilyn Perry [4] who, in 1972, was able to reconstruct the current disposition of the statues as reported in the inventories of Pellegrini and de'Vecchi inside the Archaeological Museum of Venice using also the drawings made by Anton Maria Zanetti 'the Young' in 1736. This contribution is a fundamental stage in the attempt to virtually reconstruct the original exhibition of the Tribuna. Unfortunately, Perry's study did not manage to reconstruct the exact disposition of the statues. A first and plausible hypothesis, then widely supported by critics, can be found instead in the study of the scholar Eva Soccal [5]. In her graduation thesis of 1999, Soccal hypothesised that the inventory of Pellegrini followed a circular trend in the enumeration of the statues, starting from the sculptures situated at the base of the walls and then rising helically upwards. The idea suggested by Soccal became an installation in an exhibition that took place in Bonn

in 2002 and that was dedicated to collectors and Venetian art. The images of the walls of the Tribuna were printed in a 1:1 scale and used as background for some of the original sculptures lent by the Archaeological Museum of Venice. Drawings by Zanetti were instead used as background for the sculptures that were supposedly originally placed in niches and on upper shelves.
It is probably superfluous to point out that this research [6], mainly focused on the digital reconstruction of the Tribuna, had to rely upon reconstructions made by art historians and archaeologists who have received great credit from the scientific community.
Apart from the already mentioned Soccal's study, the other most important research is *'La Tribuna ritrovata. Uno schizzo inedito di Federico Zuccari con l'Antiquario dell'illustrissimo Patriarca Grimani'* by Irene Favaretto and Marcella de Paoli. The work of the two Venetian scholars has been inspired by the finding of a drawing that apparently has nothing to do with the Tribuna of Palazzo Grimani. This drawing by Federico Zuccari is a reproduction of '*The Feast in the House of Simon the Pharisee'* made by Paolo Veronese in 1573 [7] and is preserved in the Department of Prints and Drawings of the British Museum in London. On the back of this drawing there is a freehand sketch made by the author himself which represents an image, although partial, of the Tribuna of Palazzo Grimani when it was full of Greek and Roman statues. The sketch represents the right half of the wall facing the entrance of the Tribuna. Although the drawing is incomplete, Favaretto and de Paoli have tried to reconstruct, even though only on paper, the entire room, hypothesising its organisation in the 80s of the 16th century with the repositioning of about 100 statues. (fig. 1)
Discussing the specifics of the digital reconstruction, after an intense study of the sources with the collaboration of art historians and archaeologists, the first operation carried out was a laser scan survey of the space of the Tribuna and the creation of a physical 3D model. Moreover, once the statues were positioned in their current location, some of them were surveyed using digital photogrammetry, in particular the Hora d'Autunno, which is nowadays preserved in the antitribune hall of Palazzo Grimani. They survey and modelling of all the statues was a long and complex work that involved only a few cases in this first phase, trying to build and explore a methodology that was then completed thanks to the collaboration with the Directorate of Cultural Activities and Sport of the Veneto Region, which lent the models of the missing statues. The data regarding the room and the statue obtained through the photogrammetrical survey were then processed through the software *Agisoft Photoscan*. The elaboration of the room was meant to obtain a three–dimensional model suitable to be then remodelled with a software of digital drawing in order to obtain a printable model. The elaboration of the statues was instead meant to obtain a texturised model that could be used to create the content of the application in augmented reality. The modelling made with the *software Rhinoceros* created a simplification of the digital clone of the room in terms of geometry and decorative details that are believed to be dated after 1582 – the reference year of the hypothetical reconstruction. In particular, the floral decorations at the centre of the ceiling coffers of the vault, the plaster masks placed above the round arches of the main niches and the plaster survey that adorned the mirrors above the arches were removed. In addition, the entrance on the left wall and the window on the right wall were removed for the same reasons and they were replaced with niches.
To enable the view inside the room in the printed physical model, only one half of the room was printed – that is, the one resulting from the division of the room itself by means of a plane perpendicular to the floor and passing through the vertical axis of the left and the right walls. The half that was printed is the one that contains the wall facing the entrance of the Tribuna. The model was subsequently divided into independently printable sections that were then united among themselves with hooks (between the walls, and between the walls and the sections of the vault) made ad hoc or with a glue (between the sections of the vault, and these and the skylight). After the printing phase, an application in augmented reality was created using the Unity and Vuforia *software*. In particular, Unity is a *software* that enables to create a large number of applications such as apps for mobile devices, while *Vuforia* is a kit for the development of applications in augmented reality for mobile devices. The structure of the application includes a simple main menu that introduces the augmented reality

scene and explains to the users how to use it through the 'instructions' command. That same application contains the interactive view of the original position of fourteen statues inside the Tribuna, that is, those relating to two thirds of the wall facing the entrance of the room. (fig. 2) The software Rhinoceros was initially used for the creation of the scene with the digital models of the statues to equalise the scale of the mesh models of the statues and that of the model of the room. Then, the models of the statues were virtually situated inside the Tribuna. Finally, the whole complex of the statues was exported in .obj format and imported into Unity to create the scene. Therefore, by framing the model of the Tribuna with a normal mobile device and thanks to some targets situated in the different support points of the statues, the image of the Tribuna with its statues appears. The next step consists of experimenting this application in the physical space of the Tribuna, considering the excellent functioning of the same on the scale model. The application designed in augmented reality offers interactive in–depth contents too: each statue has a multimedia card, consisting of a panel containing its real image, its representation made by Zanetti in his catalogue of 1736, and a small text with its name, its current location, and some other information. This panel can be activated for each statue by clicking on the statue itself.

Notes

[1] Cf.: Moschini 1815.

[2] Sansovino 1581, pp. 138-139.

[3] Cf.: Inventario Pellegrini, 16 november 1593 (asv, Procuratori de Supra, b. 68, proc. 151, fasc. 3, I, cc. 33-42).

[4] Perry 1972, pp. 75-253.

[5] Soccal E. 1999-2000, La Tribuna di Palazzo Grimani. Ipotesi di ricostruzione di una raccolta d'antichità nella Venezia del XVI secolo, graduation thesis, University of Padua, supervisor Graduate I. Favaretto; Soccal 2002, pp. 447-455.

[6] Part of this work has been developed in the thesis *Nuove Tecnologie per un Exhibit Museale Innovativo*, Graduate Valeria Sambucini, for the II–level Master's degree *MI–Heritage Sistemi Interattivi* e *Digitali per la Restituzione* e *Valorizzazione del patrimonio Culturale* of the Iuav University of Venice, scientific manager Prof. Giuseppe D'Acunto.

[7] For Federico Zuccari, see: Acidini Luchinat 1998 e Acidini Luchinat 2001, pp. 235-240.

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The Rock Church of San Micidiario of the Pantalica Site and 3DLAB VR/AR–Project

Giuseppe Di Gregorio

Abstract

This work gives the first results of a research project funded by the Sicily region, aimed at the creation of virtual reality (VR), augmented reality (AR) models, in the context of some country of the territory of Sicily with UNESCO listed monuments. This project sees the collaboration between some universities on the island and some partners who produce software and automated robotics systems and AI. Below are the first results of the workflow produced for the creation of 3D models of one of the three rock churches of the necropolis of Pantalica: an Unesco site. It also describes the process underway to get to the creation of VR and AR models to be used with three different levels of immersive reality: normal commercial viewers, different types of Oculus viewers, or in special virtual rooms Cave Automatic Virtual Environment (CAVE), already existing or created within the project.

Keywords
3D survey, digital survey, SFM, photogrammetry, VR/AR.

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Introduction

The ever–increasing and increasingly cheaper availability of active and passive sensors, such as 3D laser scanners and sophisticated photogrammetry systems, with increasingly versatile and feature–rich software environments, on the one hand, and fixed equipment on the other with wearable devices for the use of highly immersive environments has made it possible to create a real market of Virtual Reality (VR) and Augmented Reality (AR) which, according to the Worldwide Semiannual Augmented and Virtual Reality Spending Guide by IDC, has accelerated over the last five years, with a compound annual growth rate of 198%, to the point of reaching $ 143.3 billion in 2018. VR applications are increasingly widespread and numerous in many fields, such as: medicine, biology, automotive , manufacturing, cultural heritage, public administration, "internet of things", architecture, gaming, advertising, online sales, communication and marketing, tourism, and publishing, fashion, education, training, etc. and the emerging integration of VR into business processes such as design, production, simulation, maintenance, safety, etc. is extremely significant. It is therefore no wonder that advanced visualization VR/AR laboratories are in continuous creation and development, both in an academic and industrial environment, often with public–private co–management and that in 2017 the European Commission funded the VISIONAIR project, which had the goal, successfully achieved, to create a continental network with more than 20 VR and 3D visualization centers and to validate it with about 200 applications and projects of cultural heritage, biology, chemistry, engineering, mechatronics, medicine, and much more, selected through competitive procedures.

The 3DLAB Sicily Project

As part of a project funded by the Sicily region, the Department of Civil Engineering and Architecture of the University of Catania (DICAR) participates in the development of VR and AR models, through a research group related to the disciplines of design and representation, which intervenes for some Cultural Heritage, in the context of various municipalities already registered as UNESCO sites. Among these it is worth mentioning the country of Sortino (SR) with the important and vast archaeological site of the necropolis of Pantalica. Among the various purposes: – improve and enhance the use and enhancement of the artistic, cultural and environmental resources of the territory, given that virtual reality environments are becoming one of the impulses of tourism 4.0., – use technologies to create applications that allow an extremely dynamic and multisensory interaction of the island's cultural heritage, – create, develop, validate and promote a sustainable regional network of some centers for VR/AR and 3D visualization, – federate the infrastructure with that of VISIONAIR, in order to create visibility at an international level; – create a service that borrows the concept of "liquid lab" or "liquid studio".

Fig. 1. Pantalica (SR), exterior of the rupestrian church of San Micidiario.

The Rock Churches of Pantalica

Declared a UNESCO site in 2005, the site of Pantalica consists of the Anaktoron or prince's palace dating back to the protohistoric period, the remains of an inhabited area of the same period, about 5,000 tombs in grotticella and the remains of three Byzantine villages linked to three rock churches also called oratories. The entire site is marked by the path of two rivers, the Calcinara and the Anapo and consists of different areas defined with different toponyms. The three rock churches are those of San Micidiario, of the Crocifisso and of San Nicolicchio, located on three different sides, each serving a surrounding village. Paolo Orsi identified for these oratories a high medieval rock settlement, expression of a natural Byzantine fortress. Furthermore, the same archaeologist placed the chronology of the three churches prior to 878 [1]. Aldo Messina in updating the catalog of the rupestrian churches of Syracuse, corrected the dating by proposing to place them in the context of the Norman period. The first rock church on which attention was paid within the 3DLAB project was that of San Micidiario (fig. 1), located on the edge of a large rock village located near the saddle of Filiporto: a fortified trench. Three distinct rooms (fig. 2), communicating with each other, are part of this oratory, of which only the first two with an access from the outside. The first room is the one intended for worship and consists of a hall and a presbytery, the hall has a regular shape of about 4.00 x 2.70 m, while the presbytery has dimensions of about m 2.70 x 2.00 m, while the presbytery has dimensions of about m 2.70 x 2.00 and occurs at a greater share of the room that precedes it, the other two rooms with an almost regular plan, have dimensions of about m 3.90 x 3.80 and 2.65 x 4.24 m. In the cult environment, in the area that separates the two zone, the attacks of the rock of a pre–existing templon are still visible, which would strengthen the Byzantine origin with three openings that repeated the geometry of the apse area. Orsi tells us that he found a painted plaster in the apse area, of which only traces are visible today. The information that a poly–figurative composition existed in the apse area remains confirmed, the issue was dealt with and deepened by G. Arcidiacono [2].

The Creation of the 3D Model and VR/AR

The first phase of processing involved the use of SfM, the equipment used is a Canon full frame digital camera. To create the 3D model, the multi–image photogrammetry application SfM Zephyr by 3DFLOW was used (fig. 3). The result was a unique 3D model for the three environments, with the ability to navigate continuously within the three volumes. After checking other aspects, several elaborations followed, including the section with a horizontal plane to obtain a section in 3D. This acquisition and processing through multi–image photogrammetry is accompanied by a scan with the Faro 350 plus Laser Scanner, in order to evaluate the results for the definition quality of the rock walls, for the creation of the VR model between the two systems. The 3Dlab project involves the use of three VR CAVES. The first VR CAVE already operational, was developed by SWING:IT [3], and is used for production of applications, as part of research and development projects and for services to

Fig. 2. Pantalica (SR), the area adjacent to the oratory of San Micidiario.

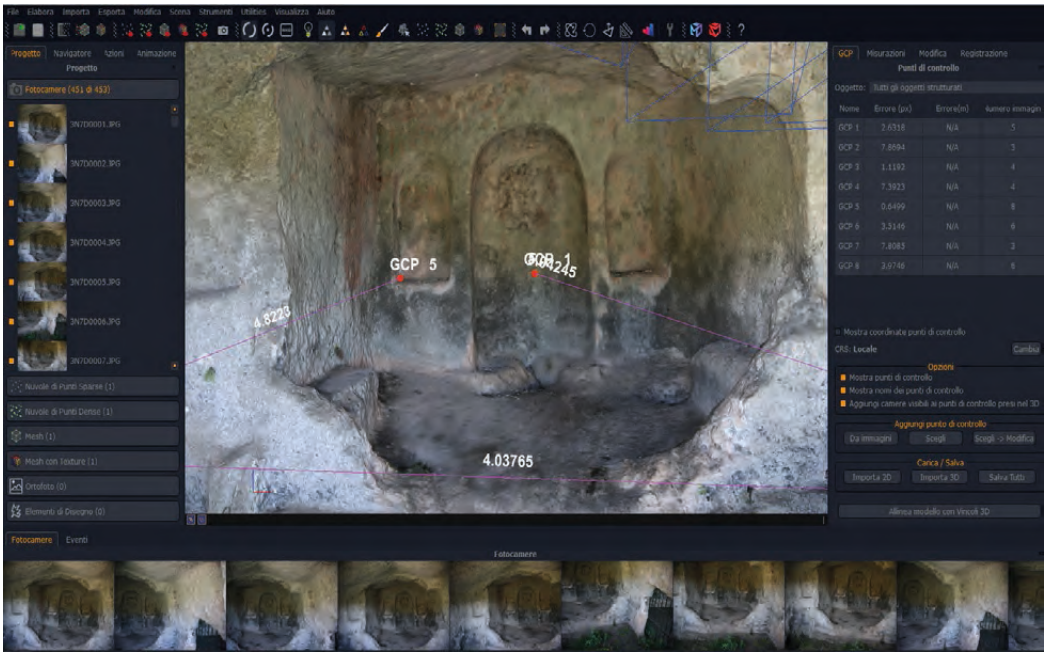

Fig. 3. Pantalica (SR), oratory of San Micidiario, the presbytery zone, Zephyr reconstruction.

Fig. 4. SWING:IT VR CAVE video projectors.

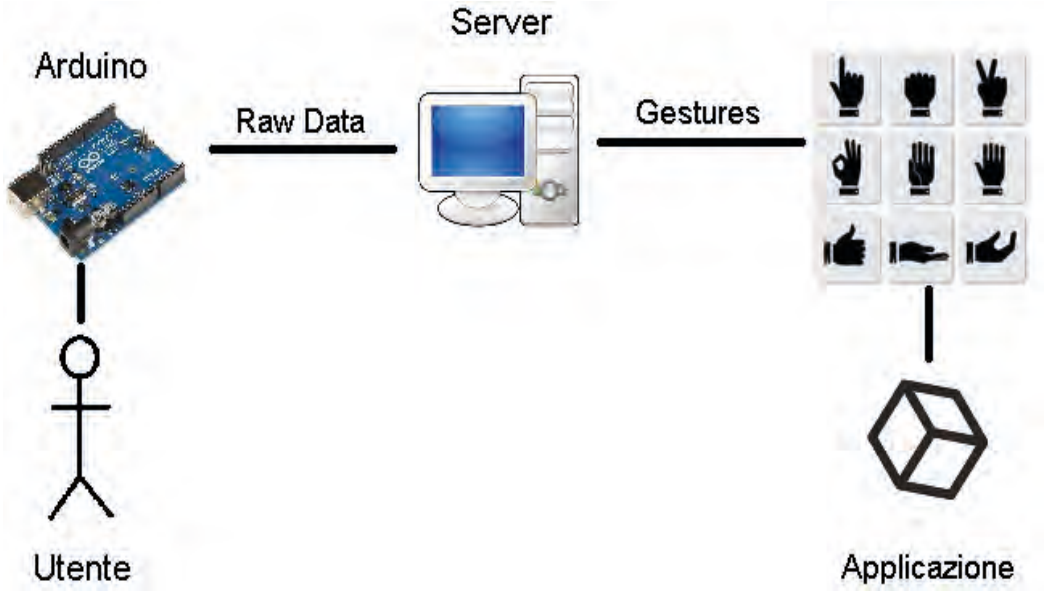

Fig. 5. Architecture of the light glove.

third–party activities that require an advanced visualization infrastructure. The Virtual Room is a structure capable of reproducing an immersive virtual reality experience IVR (Immersive Virtual Reality), organized on a video–theater inside which images are projected using 3D projectors (fig.4) and/or screens, together with appropriate 3D software. One of the strengths of the SWING:IT system is the presence of the tracking sub–system, which allows you to track the user's position, using this information for real–time recalculation of the perspective vision, thus giving the user the sensation of navigation within the 3D scene. The SWING: IT virtual room is controlled by two PC, the rendering node (Render PC), dedicated exclusively to scene rendering and the processing node (Master PC), which takes care of the software execution. Video projectors take care of projecting 3D images on the panels, with a projector for each panel. The tracking system adopted is the ARTTRACK5, a stand–alone system, which uses an infrared (IR) tracking method, equipped with a central unit that holds the tracking logic to which the infrared cameras refer. Finally, a "Pattern Recognition" system is able to determine the position and orientation of each individual marker present within the tracking area, using the Hand Track and Crystal Eyes as input peripherals. Therefore, additional input devices are being evaluated to be integrated and tested to improve the immersive experience within the Virtual Room, while avoiding introducing additional disturbing elements to users. As part of the development of the project 3DLAB, SWING:IT is evaluating the possibility of expanding the list of input devices in order to improve the immersive experience (fig. 5). The 3D scenes are created through the Unity 3D development platform, the application generated produces a video output that is managed by the TechViz XL software, which is able to view the 3D scenes without any limitation of resolution and performance.

Acknowledgements

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Notes

[1] Arcdiacono G., 2019, Le ultime fasi di Pantalica: le chiese rupestri e la loro decorazione pittorica, sta in Atti del convegno di Sortino (SR) 15–16 dicembre 2017, Consorzio Universitario Archimede Soprintendenza BB.CC.AA. – Siracusa, Scuola di specializzazione in Beni Archeologici – UNICT, Comune di Sortino, Bottega D'Erasmo Aldo Ausilio Editore in Padova, p.204.

[2] Arcidiacono G., 2019, pp. 203-221

[3] SWING IT is the acronym or abbreviation of Software Engineering based in San Giovanni La Punta (CT), and is one of the partners of the 3DLAB SICILY project.

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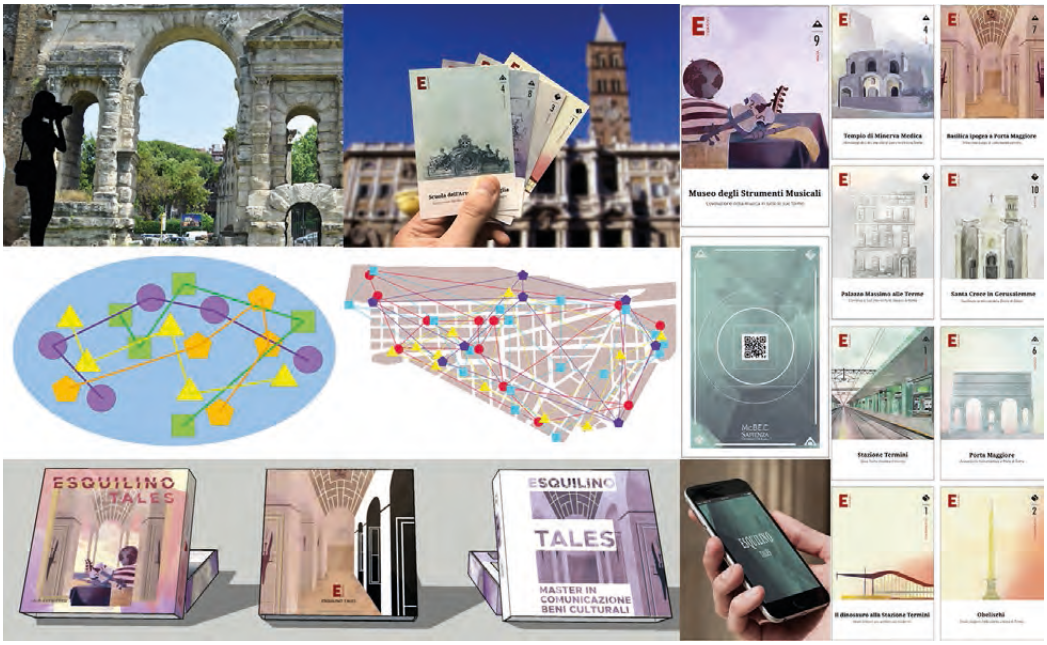
Understanding to Enhance, Between the Technical and Humanist Approaches

Elena Ippoliti

Abstract

The topics brought to attention by the Symposium provide the opportunity to reflect on research experiences in the last fifteen years where the potential of digital technology, and augmented reality in particular, has been tested to enhance the cultural heritage. It is an opportunity to verify – beyond not only the apparent kaleidoscope of the latest technological "novelty or wonder", applications, and goals, but also changing groups of scholars or case studies – the presence or lack of a driving motive with regard to both the general goals and the specific discipline of *Disegno*, thereby validating, again at a distance of several years, the different experiences.

Keywords
representation and communication of cultural heritage, representation of the city, communication and visual perception, gamification, storytelling.



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The Model

The starting point of the reflection lies in research [1] that has selected critical reflection and experimental investigation of digital technologies as a favoured area to enhance the cultural heritage by defining "visual models for knowledge and use" [2].
The first approach was mostly aimed at faithful, imitative modelling of reality, with a focus on solving problems related to the details of reconstruction – number of polygons, rendering quality, textures, lighting, etc. This setting conditioned the possibilities for online exploration, preventing correspondence with the goals of the research, i.e. publishing and sharing bodies of knowledge about the cultural heritage organized through 3D models integrated with the real, geographical, and web spaces.
Technological developments (from miniaturization of the components to identification of algorithms for data compression) already allowed for some hybrids between real and virtual, variously refined by the subject's level of interaction with the real space, presence, and type of device. In particular, the first applications of augmented reality – or more properly mixed reality – had already been developed for smartphones (having just been equipped with GPS, electronic compass and inclinometer, camera, and wireless connection), although severely limited in their integration between real/natural and virtual vision, frequency with which the virtual scene was updated, adherence of this to the real space, etc.

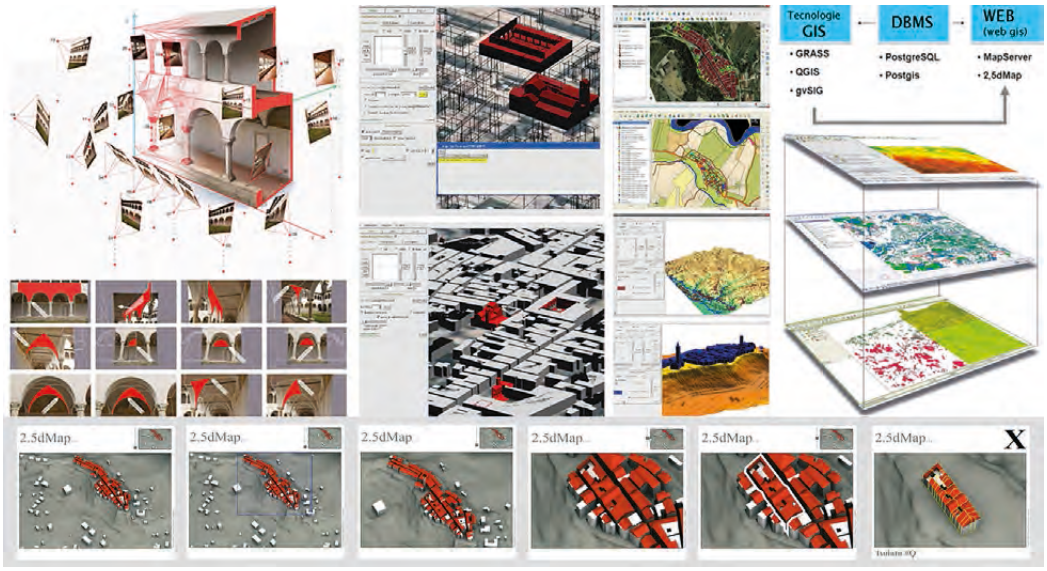

Fig. 1. The figure wants to summarize the common purpose of a set of researches: publishing and sharing bodies of knowledge about the cultural heritage organized through 3D models integrated with the real, geographical, and web spaces. From *Maps, technological and spatial models for understanding, promotion and sharing urban heritage*, PRIN 2007-2009" and *Towards the construction of a Digital Atlas for the documentation of cloisters and courtyards in Ascoli Piceno*, 2006-2008.

Nevertheless, pursuing the objectives of the research and relying on technical/procedural expedients to overcome the technological limits, we explored the entire arc of the real–virtual continuum, trying to variously combine the different terms in play (real, virtual, devices, etc.) to probe the different perceptual responses.
In some way, we practised the three–dimensional taxonomy developed by Milgram and others [Milgram et al. 1994; Milgram et al. 1995] on AR applications obtained from the entire mixed reality spectrum. In this taxonomy, two dimensions (reproduction fidelity and extent of presence metaphor) are closely related because the question of realism (or better yet, plausibility) of the scene is related to the measure with which subjects perceive their participation in the scene – from either outside or inside. The third dimension (extent of world knowledge) instead measures the subject's judgement of the integration of the virtual content with the real world. This, however, is not only a function of the viewer's exact position in the scene, but also where the intelligence of human perception intervenes to "close the cycle" [Milgram et al. 1995, p. 287].
In this framework, the "visual models of knowledge and use" were modified – from the "3D digital representation/model" to the "informed 3D model" to the "digital 3D scene" [Ippoliti, Meschini 2010] – with an ontological shift in the representation/vision from 'objective' to

'subjective', turning the observer into a spectator and then an actor, no longer in front of the representation but within the scene.
The 'digital 3D scene' became a participatory place by virtue of which one could effectively realize the construction, access to, and sharing of cultural content. Different types of 'visual 3D models' have been explored in this view for a similar number of applications and tours relying on augmented reality and virtual reality according to different degrees of interaction and/or immersion.

The Topic

In this framework, we tested different applications of AR (or, as mentioned above, MR) on very different case studies (a neighbourhood, square, set of goods with uniform characteristics, etc., but also a collection of representations of an urban space, square, etc.), all of which, however, were types of cultural goods that transmit their value starting from their state as a 'figure'. These goods should be used consistently with their specific signs in visual languages that encourage modes of exploration, thus consistent with the goals of the experimentation: interpreting the simulation of the space and the set of visual technologies for accessible, participatory, and involving communication of the heritage. The "3D scene" is therefore the key to access the cultural heritage because the emotional emphasis tied to vision activates involvement, encouraging participation and turning the cultural good into an experience.

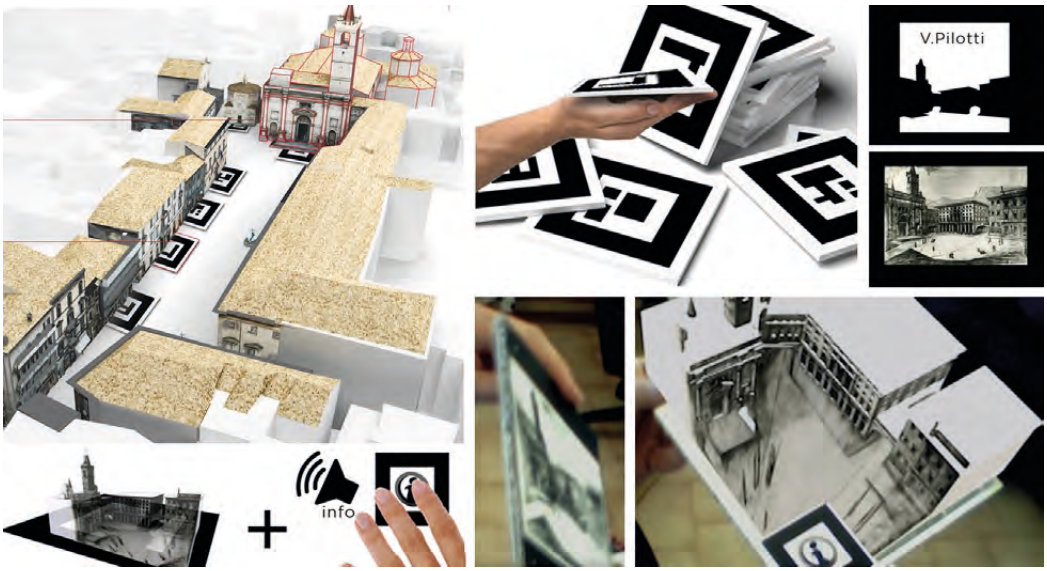

Fig. 2. AR experiences about Piazza Arringo, Ascoli Piceno. From *Informative integrated Models to know, improve and share urban and environmental heritage. Testing 3D interfaces for 'cultural and geographic objects': the architecture of the information and computerized architecture*", PRIN 2009-2012"

The case studies, however, are always anchored to the authentic motive for the research, which originates in defining the cultural good itself as the expression of the system, that is, the set of qualitative and quantitative connections between the individual goods and between these and the context. This is a fundamental awareness for Italy leading to the culture of enhancement, "in which the value of each individual monument or object of art results not from its isolation, but from its insertion in a vital context" [Settis 2002, p. 15]. The process of building knowledge therefore cannot be limited to the good in itself, but should express its interactions – both physical and linguistic – with the context where it originated, making the fabric of relationships that give it substance and clarify it explicit and tangible. It is in this context that we should begin to explore and learn about the "evidence with civic value".

The Map

Indispensable in this revisitation is another body of research focused on 'maps' [3], a logical paradigm and technically concrete place in which information is always contextual. Each datum is associated with a specific location in the map space, and it is this space itself that allows the nodes between data and positions to be highlighted. Maps are an organized form of anthropic

space that enable the complexity of reality to be penetrated through reduction into a model, but it is above all a means in which the individual parts and whole are understood through relationships, the only thing that can define the contextual meaning of the phenomenon.
These reflections led us first to experiment with the different means through which a map/representation communicates: icons, through similarity with the object, in which the information/communicational flow is continuous; and language, through signs and symbols, in which the flow is discontinuous.
These then led us to test different enunciative means of cartographic 'discourse': description and narration [Marin 2001]. In description, the gaze is panoptic and simultaneously embraces multiple points of view, expressing an atemporal spatiality. In narration, in contrast, the view is that of a traveller crossing spaces and itineraries and the points along the path follow a spatiality, expressing the temporal dimension.
The sense of the AR and MR experiences falls within these reflections. They are methods and devices to create visual models designed as interfaces to share content between the transmitter and subjects, for whom viewing becomes an experience, encouraged as they are to participate in the message of communication. The range of infographic methods only acquires a sense when viewed in light of the application of contextualizing the information, that is, the system.

Fig. 3. AR experiences about the Archaeological Museum, Palazzo Panichi, Piazza Arringo, Ascoli Piceno. From top to bottom: AR mobile device: simulations of a virtual reconstruction of the ionic column; AR desktop application: the sepulchral Epigraph of the concubine Pontia Callista. From *Informative integrated Models to know, improve and share urban and environmental heritage. Testing 3D interfaces for 'cultural and geographic objects': the architecture of the information and computerized architecture*, PRIN 2009-2012".

According to this visual, the common thread crossing and linking earlier applications and many more recent ones is very clear: the conviction that representing the inhabited space is still a necessity. This conviction expresses the primary goal of the research, i.e. reinterpreting urban representations, thus taking advantage of all the opportunities offered by visual technologies. It means revisiting the 'representation of the city' because due to the emotional relationship historically tying communities to places, it may still today be a vehicle of emotions for suggesting histories and interpretations, an interface for initiation to knowledge about values and deeper meanings of the city and cultural heritage, and therefore an indispensable tool for its enhancement.

Conclusion

This revisitation has shown that the role of technological innovation, and AR in particular, has always referred to the goals of the research: collaborating to build knowledge that can be used and enjoyed by a broad public, testing perceptual interfaces that lead to an increase in levels of the subject's interaction with the cultural good. The research therefore features the general goals of identifying 'visual models of knowledge and use' of the goods that are clearly based on rigorous means, but also amplifying the representative sense, using the most useful technologies to do so.

More in general, different research projects have used AR (recently integrated with the techniques of storytelling, gamification, and storydoing) [4] to transform knowledge about the cultural good into an act of enhancement, and therefore the "visual models of knowledge and use" into an 'experience' not only of the individual object, but of the whole, that is, the system of relationships. This general goal is the starting point for designing paths of historically and culturally consistent meaning to explore "evidence with civic value".
The applications of and motivations for the experiences are all framed within a single horizon that interprets the specific discipline of *Disegno* in which the role of informational datum is continuously exchanged with the role of the image, which not only represents it, but embodies it in its essence [Cervellini, Ippoliti 2005, p. 75]. By virtue of its spatial/topological connotation, the image renders information by giving it a form at the intersection of three themed objects: the model (iconic), map (also a type of model), and topic (in the enunciative meaning still a model). This common thread – very long, invisible, and indestructible – "can be disentangled without undoing everything" and in which "even the smallest fragment can be recognized" because it pertains to the system [Goethe 2011, p. 187].

Notes

[1] For reasons of space, the research referred to in this article cannot be detailed. See, however, the notes, references, and figures. Many researchers have participated in different experiments, including Francesco Cervellini, Alessandra Meschini, Daniele Rossi, Mariateresa Cusanno, Annika Moscati, Jonathan Sileoni, and Danilo Spinozzi at the University of Camerino, and Andrea Casale and Michele Calvano, Cristian Farinella, Lorena Greco and Stefano Volante at the Sapienza University of Rome.

[2] Among these research projects, the primary ones include *Maps, technological and spatial models for understanding, promotion and sharing urban heritage*, PRIN 2007-2009, coordinator Mario Centofanti, University of Camerino research unit leader Elena Ippoliti; University of Camerino project *Towards the construction of a Digital Atlas for the documentation of cloisters and courtyards in Ascoli Piceno*, 2006-2008, principal investigator Elena Ippoliti.

[3] The primary research includes *Informative integrated Models to know, improve and share urban and environmental heritage. Testing 3D interfaces for 'cultural and geographic objects': the architecture of the information and computerized architecture*, PRIN 2009-2012, coordinator Mario Centofanti, Sapienza University of Rome research unit leader Elena Ippoliti.

[4] These research projects include the Sapienza University of Rome project *Between museums and cities: 'cultural heritage at play' between edutainment and gamification. The role of representation between a technical and humanistic approach*, 2020-2021, principal investigator Elena Ippoliti; *Usage/knowledge systems in museum communication*, 2018-2019, principal investigator Andrea Casale; *Representations of cities and cultural identity. New guides between digital technologies and visual itineraries for the enhancement of the city's cultural heritage and tourism*, principal investigator Elena Ippoliti.

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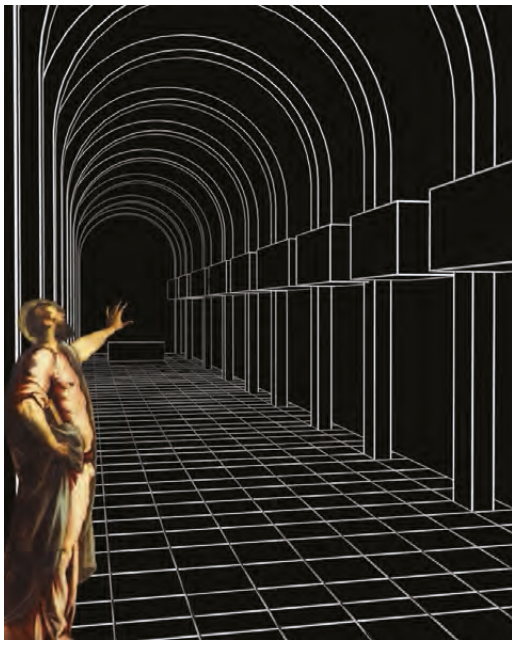
Illusory Scene and Immersive Space in Tintoretto's Theatre

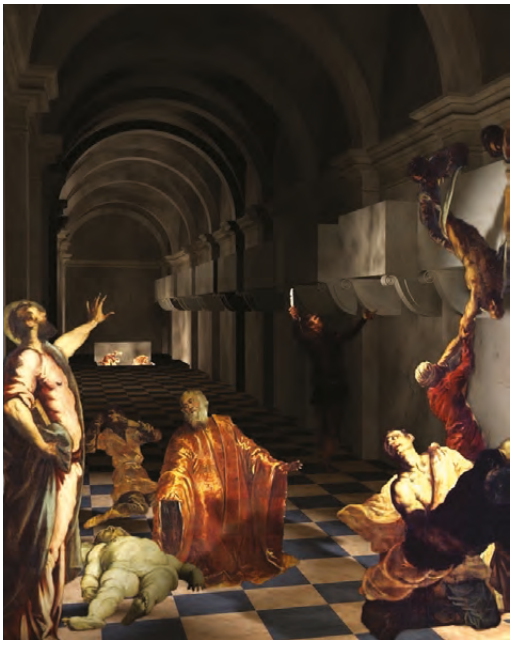
Gabriella Liva
Massimiliano Ciammaichella

Abstract

The perspective analysis of some canvases by Jacopo Robusti is the result of a research which involved, within the University of Padua, architecture and art historians with representation scholars, to share knowledges about one of the most important Venetian artists of the second half sixteenth century. The study, continued in collaboration with the Iuav University of Venice professors and students, focused on an exhibition proposal at the Sala Capitolare of the Scuola Grande di San Marco in Venice, where hopefully some of paintings will return to their original destination.
The main objective concerns the creation of an experiential itinerary, organized by a sensitive narration that starts in the same act of its fruition, to allow the observer a critical interaction dependent on knowledge process of the works and their evoked spaces, without the aid of controllers or digital viewers.

Keywords
Tintoretto, architectural perspective, exhibit, video mapping, scenography.





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The essay documents the results of a research aimed at enhancing the artistic and cultural heritage offered by Tintoretto's work, through an exhibition mode able to guarantee a knowledge experience increased using advanced digital interaction devices.
Starting from the most up–to–date artistic historiography of Tintoretto's work, the analysis conducted highlights the Venetian artist's relationship with architecture, which has remained unexplored or limited to a few essays that underline an uncommon spatial research. Considerations of the scholars Sergio Marinelli, Erasmus Weddigen, Michael Matile and Martina Frank have laid the basis for a further in–depth investigation of the relationship established by Tintoretto with the painted space, based not only on a precise knowledge of built architecture, but also on a profound admiration for the theatrical scenic space [Marinelli 1980, Weddigen 1991, Matile 1996, Frank 1996].
Following the *renovatio urbis*, imposed by the Doge Andrea Gritti – for which the reconfiguration action of Venice image is evident –, the theoretical and material examples due especially to Sebastiano Serlio and Jacopo Sansovino, together with the uncontested contact with Tuscan–Roman figurative culture, become a source of inspiration and pictorial transposition of the urban environment proposed by Tintoretto.
In his early paintings the architecture interest took on a secondary role, relegating it to the background of the narration, but from the mid–Forties of the sixteenth century, with the Christ among the Doctors, Christ and the Adulteress and Miracle of the Slave, the architectural space component became an integral part of the composition, which focuses on linear perspective. This method is understood as a technical and conceptual means of controlling the spatial configuration, aided using *papier–mâché* maquettes in which the painter, according to Carlo Ridolfi – who met Tintoretto's son, Domenico – placed wax and clay statuettes to verify the position of the characters dressed in rags, on which he carefully elaborated folds and poses of the limbs. In other cases, if necessary, he increases their scale and suspends them with wires from the beams to check their foreshortening, then he builds "small houses and relief–perspectives made of boards and cardboard, inserting small lights for the windows" [Ridolfi 1648, p. 7] and uses candles to simulate the different light sources to be reproduced in the painting [Marinelli 1980, p. 319].
This research, found in the scenic practice, can be traced back both to his theoretical education, which took place in Sebastiano Serlio's books in which we find descriptions of the performant spatiality and indications on the arrangement of lights, and to the painter's familiarity with theatrical spaces and, in particular, his friendship and frequentation of Ruzzante, Pietro Aretino and Andrea Calmo [De Vecchi 1972, pp. 101-132].
It is evident that the influence exerted by Serlian representations of ephemeral theatrical scenes – combined with the architectural practice and perspective skills of the Bolognese architect – adheres to Sansovinian petrified translation of Doge Gritti's idea, leading Tintoretto to transform the painted space into a credible urban stage on which to place the biblical narrations.

Research and Case Study

The research establishes the aim of analysing the coherence, verifying the precision of perspective technique used, also reflecting on the intentional deformations and pictorial corrections chooses by Tintoretto, in a strategic and controlled approach, especially in his more mature works. A predominant architectural component is evident in these words, and so we have tried to understand: the relationship with the biblical events narrated; the scenic setting in which the painted architecture becomes the structuring foundation of the entire composition; the visual and physical kinematic, regulated by the point of view of the observer forced to move in the multiple narration of the *mise–en–scène*. The implementation of precise perspective rules offered the possibility of restitution the painted space, with a rigorous inverse method and with adequate mathematical modelling software, demonstrating, in enhancing the written historical evidence, the real possibility that Tintoretto used real small–scale maquettes, necessary to compositions design in which to insert the lights and then the characters that inhabit them (figs. 1-2).

The canvas dedicated to The Miracles of Saint Mark is part of the chosen case studies and represents a masterfully constructed setting, made even more credible when associated, in Weddigen's hypothesis, with two other masterpieces: the Removal of the Body of St Mark and St Mark Saving a Saracen During a Shipwreck, in its primordial composition [Grosso Guidarelli 2019, p. 106]. If it is considered singularly, or in a unitary perspective strategy, at the moment of its appearance inside the Sala Capitolare of the Scuola Grande di San Marco, it aroused particular astonishment, if not the wonder ensured by the attempt to merge the hall real space with the place of the depicted scene. The context is represented by a majestic old–style portico that rises above a polychrome chessboard floor, making the articulated composition not immediately intelligible.

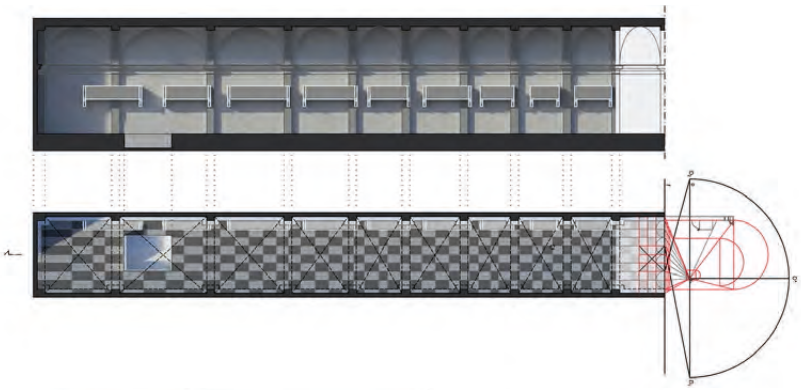

Fig. 1. The Miracles of Saint Mark, perspective restitution [Gabriella Liva 2020].

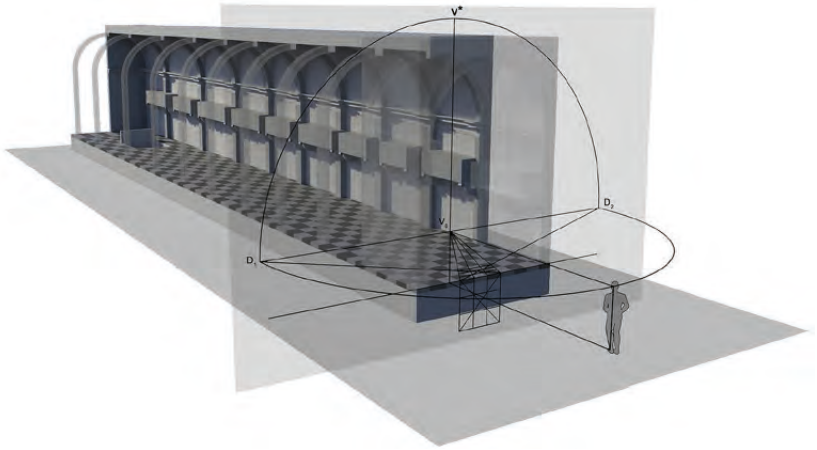

Fig. 2. Architecture reconstruction and perspective configuration [Gabriella Liva 2020].

As with other works, here we are not dealing with a static setting relegated to a simple background, but with a geometrically structured space in a direct dialogue with the characters who activate it, participating in their actions or accompanying the viewer in specific painting areas, so as to encourage a multiple reading of the events narrated. The study of the work included a detailed analysis of the various compositional elements that make it up, the identification and classification of which become of primary importance for the exhibition layout proposal. Inside the space, punctuated by the rhythm of the cross vaults interspersed with large round arches, "there appear in a long portico many sepulchres hanging on the walls, drawn by a beautiful perspective" [Ridolfi 1648, pp. 14-15], whose orthogonal profiles to the painting converge towards a single vanishing point. It is positioned on the left side in correspondence of the pulse of the saint who indicates, to the viewer, the recognition of his body. The characters depicted are distributed along the nave, according to three registers: in the foreground a group of people is represented on the right, including a possessed man taken from behind and breathing sulphurous vapours; in the centre the client Tommaso Rangone kneeling and, on the left, the majestic figure of St. Mark in the act of revealing the discovery of his earthly body; then the viewer assists the extraction of the body from the hanging sepulchre and, in the background, the vain search for the body of the saint inside an earthly sepulchre.

Methodology

Considering the narrative sequence of painted events, the study, continued in collaboration with University Iuav of Venice professors and graduating students, focused on an exhibition setting proposal and visual entertainment to be reproduce in the Sala Capitolare of the Scuola Grande di San Marco in Venice, trying to retrieve the close relationship between the real space of the hall and the illusory space evoked by represented scenes (fig. 3).
The main objective concerned the creation of an experiential itinerary, organized by a sensitive narration that starts in the own act of its fruition, such as to allow the observer a critical interaction depending on the knowledge process of the works and the geometries evoked by their spaces. The installation includes the projection of multimedia contents, to be displayed on semi–transparent screens, and it can narrate the compositional structure of the works in a controlled deconstruction of the significant painted elements.
Protagonist is the video mapping: it marks the times and dynamics of a possible and credible *mise–en–scène*, inside an autonomous stage, hosting different multimedia systems necessary to the experience. The visitor is led by a light path and voice of an actor in catch a show that opens its perspective–linear registers, hastening the visualization of material physicality of the environments, in which the protagonists of the works are animated by geometric transformations typical of image warping.
According to this exhibition logic, this following proposes an immersive fruition path, aimed to enhancing the interaction and knowledge of the inestimable artistic and cultural heritage offered by Tintoretto's works, in a close to theatrical dynamics approach [Propedo 2020]. A stage, extended along the short side of the room and about 26 meters long, rises from the floor to a height of 1.4 meters to allow viewers to frame the three works showed and po-

Fig. 3. Exhibition setting proposal, Sala Capitolare of the Scuola Grande di San Marco, Venice (Thomas William Propedo, 2020).

Fig. 4. Visualizing Tintoretto film frames (Thomas William Propedo, 2020).

sitioned in their original location, so as to enjoy them from their correct points of view. But this happens only at the conclusion of a specific narrative experience that anticipates the digital act of knowledge, mediated by a filter on which animated sequences are projected. It is possible to enter in the dark room guided by the cone of light emitted by a spotlight that invites the viewers group to place themselves in the correct positions, each equipped with people counter sensors that have the purpose of monitoring the access flow and activating the video projections on motorized semi–transparent screens, placed parallel and at a very short distance from the canvases.

Conclusions

The experience is combined by the voice of an actor, involved in three performing acts aimed at the decomposition and reconstruction of the peculiar characteristics of the works: the first one recalls the historical context and the significant steps that determined its realization, the second one describes the scene and the character roles involved in it, the third one analyses the pictorial, perspective and light techniques used by the artist (fig. 4).
The scene space questions the value of virtual and augmented reality devices, commonly understood as interaction filters with real artefacts, to enhance the learning act about the works which, in this case, are only revealed in all their tangible originality at the end of the experience. The expectation activated by the entertainment, planned within an multimedia guided scene, is confronted with the astonishment of the direct works observation, inviting to reflect on their skiagraphy knowledge, just when the lights turn on and every filter disappears to reveal and paying tribute to the inestimable originality of Tintoretto's tangible works. Even if the place appointed to host them, "the same for which they were created and which declares their unitary conception, preserved from generation to generation, and so to speak from brush to brush, therefore has become over time less important than the processes of musealisation and decontextualization of works of art" [Settis 2017, p. 37].

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Medma Touch, Feel, Think: Survey, Catalog and Sensory Limitations

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Antonio Gambino

Abstract

The project is named 'Medma Touch, Feel, Think – Technological retrofit of the Archaeological Museum of Medma–Rosarno for the 3D catalog of the exibits works on display and the possible use by subjects with sensory limits'. We have carried out the 3D survey of all the main finds with analytical photo–modeling techniques, their scientific cataloging on ICCD's specifications, the creation of a website with a high interactivity content and an Application that allows the sharing of extended informations for blind people, through the combined use of analog 3D models and AR authoring software.
A sustainable initiative, a driver for the technology transfer of innovation (often invoked, but rarely implemented), capable of generating 'social empowerment'. The methodology can also be shared by small entities, but characterized by contents of high historical and cultural values, expecially if they are able to build–up a territorial network of high identitarian values.

Keywords
photo–modeling, scientific cataloging, inclusion, sustainability.

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The Project rised from a proposal of the of Rotary International District 2100 (which also funded it extensively) and collects a broad institutional and social partnership: The ABAP Superintendence of Reggio C. and Vibo Valentia (a special thanks goes to Fabrizio Sudano, pro tempore manager of the Museum), the Italian Union of the Blind and Visually Impaired (UICI), The City of Rosarno, The Metropolitan City of Reggio Calabria, Terna SPA (which has effectively contributed to the financing) and many other Bodies and Associations that have contributed in different ways over time [1][2].
The Archaeological Museum of Medma–Rosarno is located in the archaeological park, in the town of Rosarno, full of olive trees that define its historical image in close connection with the actual perception of the territories, much like as they have been described directly by Paolo Orsi [Orsi 1913, passim] at the beginning of the last century on the occasion of the first major excavation campaigns. The exhibition is divided into three main sections.
It starts with the reconstruction of the necropolis: the different types of tombs are reconstructed, while 10 small showcases – intentionally shaped in such a way as to recall the cemetery "niches"– contain a small but significant sampling of the sepulchral equipment. It then continues with splendid specimens of medmean coroplastic findings –statuettes of different sizes and shapes–, busts, large masks, cryophores, vases, and iron weapons found in the sacred area of Calderazzo, presented on the sides of a virtual 'Via Sacra'. The last room contains the materials from the town, including a ritual fountain in terracotta and objects from the Giovanni Gangemi private collection, donated to the State, which consists of valuable vases with both black and red figures, including an amphora with scenes from the struggle for Achilles' arms.
The project can be summarized in five fundamental keywords.

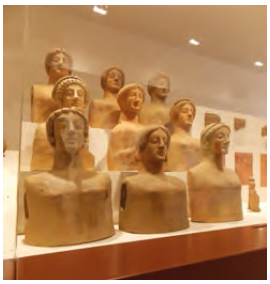

Fig. 1. The Medma–Rosarno Archaeological Museum in Rosarno (RC).
a. The large hall shaped like an ideal "Via Sacra" and, in the background, the s.c. "Arula Tyrò".
b. The large feminine terracotta busts showcase, from the sacred area of Calderazzo.
c. The "Necropolis" hall: "pano view" from the Virtual Tour materials. (Ph. Gianluca Milasi). Note the "LOGES" tactile paving path set up by the project in the museum.
d. The s.c. "town hall", with the findings from the Gangemi collection.

Surveying and Cataloging

Over one hundred and fifty exhibits were surveyed with analytical photo–modeling techniques, reconstructed, and scientifically cataloged in a digital environment. The results, in terms of geometric precision and chromatic accuracy, are very satisfactory. The scaling and geometric verification of the models are carried out through the use of a calibrated tablet which contains 30 markers of known coordinates singularly distinguishable by 12–bit encoding (fig. 2). The

markers have different sizes, to be significant regardless of the shooting distance and to ensure rigorous verification of final residual errors. The precision obtained is firmly attested in a sub–millimeter range which makes the models themselves coherent with the 1:1 scale survey. From the chromatic point of view –a critical factor in consideration of the particular nature of the relieved objects– excellent results were obtained thanks to a controlled shooting environment and post–production of the photos, that included the 'masking' of non–essential elements for the restitution.
The use of high–resolution cameras leads to very accurate modeling, which permits to push the analysis of single the objects to a very high level of detail, significantly expanding the possible critical data collection in fractions of time, if compared with any direct analysis, and at a very higher level of security (fig. 6).
In many occasions it has been possible to extend the survey to the entire object surface (internal/external), making it the complete 3D analysis of the object immediately available, including the direct measurement of significant points of interest straight from the model, the automatic extraction of profiles, etc. (fig. 4).
After a pre–cataloging phase based on the use of QR–Code and historical inventory numbers, an actual catalog form has been compiled, compliant with the ICCD specifications (RA–3.00) which permit direct compatibility with national databases on cultural heritage (fig. 3).

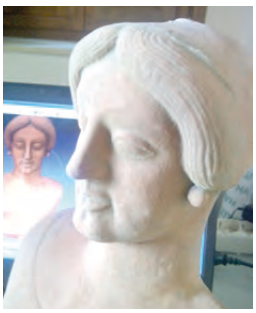

Fig. 2. Votive altar, (aka "Ara della Fenice") upon the calibrated grid.

Fig. 3. Catalogue form on ICCD specification.

Fig. 4. Ortoprojection and perspective section of a red figure vase. (invent. 141437).

Fig. 5. Full color 3D print reproduction of a medmean feminine bust.

Fig. 6. 3D model (front) and a study of the actual deviations between the original point and the final mesh.
"Overall surveillance" by a 5th century b.C. small Satyr bronze.

3D reproduction

Three–dimensional reproductions were made on one side to, somehow, replace certain important finds transferred to other museums and, partly, to be used in an interactive application for people with sensory disabilities, both through direct full–color 3D printing in real scale and through a more 'traditional' procedure of sculpting reproduction controlled by the digital model, used for larger objects that were "oversize" for the 3D printing available technology (fig. 6).
The final results, in terms of geometric precision and color accuracy, are very satisfying.

Sharing and WEB

A website has been created in a standard environment (WordPress) and permits to retrieve information about the museum, consult the multimedia catalog, and explore (or download, subject to proper authentication) the three–dimensional models at different resolution. Full–res. models in 3D/.OBJ format are available (millions of vertices point clouds, 100 Mb or more), but we are working on smaller size models (around 1 Mb) in the GLB format by resampling the textures to grant sharability over smartphone even at a very low band connection. We are also

Fig. 7. Medma touch, feel, think App. From RAI TG–R reportage. Special thanks to RAI journalist Giulia Bondi and to Marika Meduri, president of unsighted association of Reggio Calabria (app. tester).

formalizing a partnership with the IIIF consortium to reach complete control over the distribution of patented 3D models. The site also provides a high level of multidisciplinary interactivity allowing specialists and scholars, through Wiki–type pages, to collaborate with the implementation of the descriptive part of the forms. Finally, it contains a complete virtual tour of the museum, which is currently being programmed to allow a direct visual consultation of the catalog.

The Touch, Feel Think App

The core commitment of the project was addressed through the implementation of an application for unsighted persons, based on the use of high–resolution webcam and motion detection techniques that allow a completely hands–free approach.
It starts with the 3D models (fig. 1, 7a, 7b, 7c). People approach the replicated object and touch it without any restrictions: the system recognizes the touch and plays a first general soundtrack which introduces the historical framing of the object, and afterward, if the exploration continues, gradually recognizes the parts that are progressively touched: the description can then continue in detail, giving an account of many details that can create curiosity and encourage a scientific deepening of the knowledge of the assets, as well as their contextual conditions. The whole process is developed in an authoring environment, by which the signals coming from the cameras through the definition of any number of sensitive areas (hot–spots) can be hierarchized and can lead to a really effective storytelling program. The system also implements directional ultrasonic loudspeakers, capable of containing noise pollution in the museum by limiting the sound flow to the single users. Feedback in application testing reported a very comfortable perceptual experience. The novelty of this approach lies in the alchemical engineering of standard technologies, widely available, but not yet applied in cultural heritage environments, to achieve shareable, but very effective, results at low cost. In this case, it is of great interest the integration between motion recognition technologies with the programmability of the software capable to create a single environment for authoring multimedia contents of high semantic value, dependent on the tactile interaction between the object and the blind perceiver, thus creating a real virtual/analog bridge independent of the technological mediator on the end–user side.

Conclusions

The project is currently concluded in its prototype state and has already produced many positive feedbacks, even in this early stage, developing a profitable process that has brought together public institutions and private initiatives in a very effective synergy, characterized by a remarkable transversality.
One of the main results of this synergy was the positioning of the idea itself at the base of a further project included in the so–called 'Living–Lab Program', bottom–up initiatives financed by the European Community, directly arising from the territories as long as certain issues are perceived as strong, positive instances by the communities. A consortium has been therefore established between University and private companies for the industrialization of the prototype, within a more general enhancement action of the Museum and the Archaeological Park, that is taking shape in these very days.
The project, in this new phase, has led to the creation of an Association (ATS) between the PAU Department [3], which participates as a Research Body, and private companies active in the sector of protection, promotion, and safeguarding of cultural heritage.

In the future, we plan to integrate into the system motion sensors with capacitive proximity devices (NFC, etc.), also through the field testing of new sensors based on the very high transduction capacity derived from the use of Graphene materials in the surface treatment of analog 3D printed models, aimed at maintaining the hands–free approach that was greatly appreciated in the testing phase in a non–immersive environment.
Beyond the specific contents of this projects, and of the new ones, we strive to combine innovation, scientific rigorous approach, and enhancement of cultural heritage through an 'inclusive attitude', where the word 'inclusion' is purified of any declination linked to the idea of the 'due by law', or, even worse, to the one of 'charitable intervention'. Cultural inclusion, and generalized fruition capabilities, on the contrary, must be intended, as they are indeed, directly connected to the economic strengthening of initiatives and territories and a powerful drive for development.
This approach presents itself immediately as highly sustainable, not just being self–financed, but, thanks to the strong idea of transparent (and inclusive) commonality of all the project revenues, it can directly function as a medium for the transfer of technological innovation (often invoked, but rarely actually implemented) and generates a condition that we like to call 'social empowerment'.
The entire procedure becomes immediately shareable and the methodology can also be at disposal of "limited size" cultural institutions, such as small museums, or even private collection, which are, on the other side, often bearers of the highest historical and cultural values, particularly if, together with their hosting communities, they would reach to build some territorial networks of high local identity values.

Notes

[1] Rotary International – Disctrict IT–2100: D.G. 2014-2015 prof. Giancarlo Spezie; D.G. 2017-2018 dott. Luciano Lucania. Rotary and Rotaract Club Reggio Calabria and Nicotera–Medma. Special thanks to: arch. Salvatore Patamia, MiBACT; arch. Pietro Vicentini (Terna); ing Giusesppe Fedele (UICI Reggio Calabria); Prof. Giuseppe Lacquaniti (Historian and Journalist).

[2] The Project has bee carried out by a group of young resources selected by public evidence from the Rotaract area and the Mediterranean University: Angela Balestrieri, Gabriele Candela, Barbara Cusato, Giuseppe Cutrupi, Roberta De Clario, Fabio Panella, Danila Punturiero, Verdiana Quattrocchi and Peppe Sorrenti. The operational coordination has been performed by Technical Tutors with consolidated experience: Antonio Gambino, Marilù Laface, Andrea Manti, and Roberto Prampolini for the web content.

[3] The 'EcoMedma' consortium consists of Ecolandia SCARL (Leading Company, Pres. Prof. Antonio Perna), The PAU Department of the Mediterranean University of Reggio Calabria (Research body, Dir. prof. Tommaso Manfredi), CADI SRL (Dir. ing. Piero Milasi).

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The Emotion Detection Tools in the Museum Education EmoDeM Project

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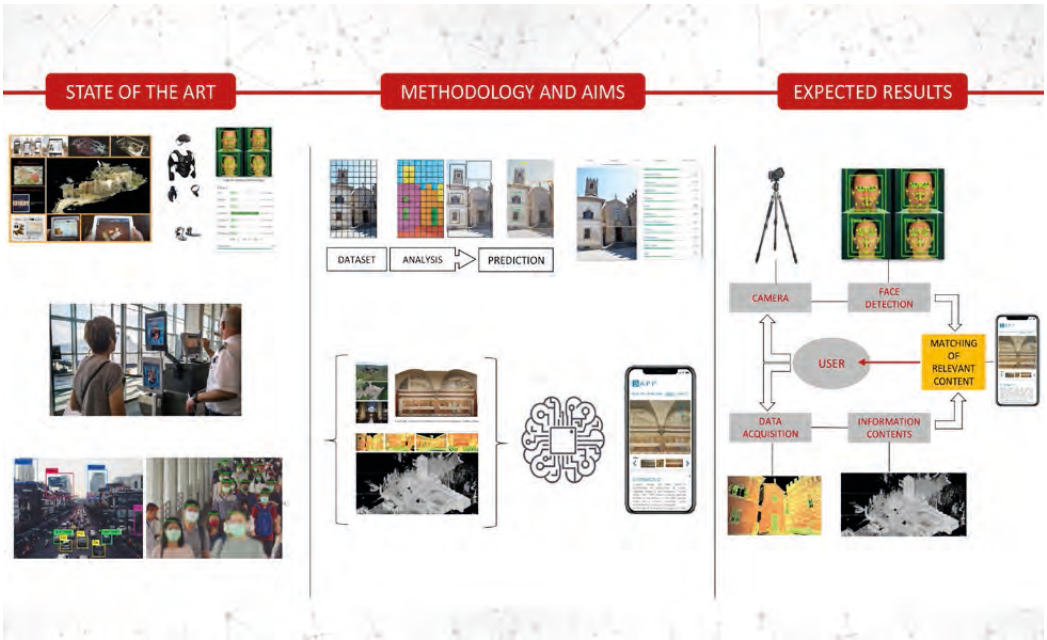
Abstract

Facial recognition technologies, already used nowadays in many applications, i.e. to support security systems in sensitive buildings, could in a short time achieve widespread use also in others sectors including culture institutions like museums or art galleries.
The state of the art in the field of facial recognition allows discriminating factors not only related to the essential somatic characteristics of a person to recognize, with an ever–greater degree of precision, the emotional reactions that may occur on person's face.
The article intends to describe the research's EmoDeM experimentation in the museum environment in order to provide a tool capable of interpreting the reaction of a user in front of an artwork and propose a responsive information content coherent what is manifested through facial expressions.

Keywords
digital heritage, museum education, machine learning, image classification, emotion detection.



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The most important national and international cultural strategies clarify the importance of actions that include the use of digital languages and virtual environments allowing visitors to better understand the informative features about the observed objects and contexts. The hybridization of traditional spreading methodologies with the tools offered by contemporary digital languages in the field of cultural heritage education therefore becomes an essential asset for those who work in the field of spreading of tangible and intangible values of the cultural heritage [COE 2005; New European Agenda for Culture, European Commission 2018]. The most innovative aspect is not solely in the technological advancement of the supports used to collect, record and transmit information: the kind of digital contents, their being an informative material whose language has a communicative shape with potential and effectiveness only partially investigated, makes their experimentation absolutely central in the contexts connected to education and enhancement like museums and cultural heritage institutions. In fact, digital data has taken on a role not new but certainly enhanced in the current meaning of cross–media contents and effective integration with traditional museum educational tools [COE 2018; Work Plan for Culture 2019-2022; Council 2018]. The experimental use of new media and A.I. in the EmoDeM project represents, from this point of view, an attempt to further advance in the dissemination of cultural heritage as an integral *pivot* of society and human knowledge.

Field of the Research

The EMOtion DEtection Museum project – EmoDeM concerns a study using some AI applications in the museum environment to provide valuable indicators for museum education. Among the multiple thematic axes of the project, also relevant in negative terms, some can be identified as priorities:

- the cultural axis relating to the EmoDem's human–centered characterization of 'AI for society' as explicitly pursued by the EU "Between 'AI for profit' and 'AI for control', Europe could embrace 'AI for society', a human–centred, ethical, and secure approach that is true to our core values" [Annoni et. al. 2018];
- the scientific axis of the multidisciplinary concept focused on the Survey discipline and its various articulations: Architectural Survey (as a tool for acquiring and representing data for the knowledge of historical contexts), visual communication and digital storytelling;
- the axis of the regulatory policy concerning privacy issues, the governance of the data sharing ecosystem and the management of information.

Aims of the Research

The article illustrates the early stages of the EmoDeM study consisting of the application of facial recognition technologies to museum education [Li, Li 2020, pp. 1-25; Baraldi et al. 2015, pp. 2705-2714]. These AI functions are used to detect and interpret the facial expressions of the visitor in front of the exhibited artwork to propose a content corresponding to what is manifested [Artstein et al. 2014]. The project foresees that, by comparing the images acquired by an 'intelligent' shooting system in the immediate vicinity of the visitor with a dataset of pre–selected and classified images, it is possible to identify and classify with a good reliability the visitor's reaction and consequently propose an information content identified in the connected and predetermined repository as 'associable' to the expressed facial expressions.

State of the Art

The state of the art in the field of facial recognition allows discriminating factors not only related to the somatic characteristics of an individual: there are several experiments in which a software is instructed to identify the emotional states of the framed subject arriving at recognizing, with a constantly increasing degree of precision, the emotive reactions that can be

manifested on the face of an individual (amazement, curiosity, attention, etc.) [Sharma 2019, pp. 834-837]. Facial recognition solutions that use Machine Learning programming are built on a sw models based on the analysis of large information datasets, called Training Datasets, and on the identification of recurring patterns inside it [1] the machine can therefore employ what it has learned from the analysis of the datasets to making autonomous predictions and choices without explicit programming instructions [2] [Alpaydin 2020]. Research and experimentation in the field of machine learning have been demonstrating that the simulation performances of the human processes are currently very unstable as the detection is not always correct and reliable and yet the phases referring the identification of the components of a specific problem, the comparison, the definition of a result, the refinement of the degree of reliability are in very rapid evolution [Alpaydin 2020]. This suggests that software of facial recognition currently used to support the security systems could soon also be used in different scenarios like museum education [Duguleană et al. 2020, pp. 1-17].

Methodology

The methodology used in EmoDeM integrates a workflow of operations divided into three macro–phases: 1) acquisition of facial expressions; 2) image analysis and emotion detection; 3) response of the software through the matching of coherent contents. The first phase of the process has been the data acquisition using a video camera placed near an artwork, used to acquire the visitor's facial expressions [Fyffe et al. 2016; Legendre et al. 2018, pp. 1-2]. The captured image has been subsequently processed therefore starting the emotion detection sequences. This phase certainly represents the most relevant and innovative part of the application as uses specific Machine Learning solutions responsible to evaluate the facial expressions detected and the visible visitor's reactions. The purpose of a machine learning program is to provide a computer with an algorithm consisting of a series of elements that can be compared in order to establish general criteria to learn from and to rely on in subsequent queries. For this purpose, it's essential to develop datasets consisting of many specific data including the significant characteristics to be correctly interpreted from the software during the preliminary training phases. Therefore to enhance the sw detection, in addition to the images directly acquired from the authors during the test, EmoDeM will employ specific datasets expressly designed for emotion detection applications, i.e. CK+ [3] [Lee, Kang 2020, pp. 15-27]. In its complete configuration the last output of EmoDeM is the proposal of relevant contents coherent to facial expression.

First Results

The technical solutions used in the EmoDeM study have been inspired from the results obtained in a previous research on the documentation and spreading project about the abbey of Badia a Passignano [Nicastro 2020]. At the end of that experience, an enhancement project was drawn up whose AI images detection functions have been later integrated into the EmoDeM study: in the first research an application was developed to provide information for the visitors of Badia a Passignano [4]. For intrinsic reasons, the architectural components are, however, characterized by visual patterns that are much more easily typified than those characterizing a totally inhomogeneous and variable set such as people's facial expressions; this constitutes the major limitation of the test, illustrated below also in the failure aspects. At present, the experimentation phase relating to detection in a simulated environment was held, the purpose of which was to verify the degree of confidence of the software in the correct classification of the apparent reactions shown by the faces of people photographed in front of a pictorial work. For this purpose, a set was set up in which 6 participants were invited to observe three different reproductions of pictorial works. A smart workstation was used to capture the images of facial expressions, catalog and analyze them with the Google Cloud Vision API software. Once the acquisition phase was completed, the subjects involved were asked to fill in a questionnaire in order to explicitly indicate the reactions felt during the test, then comparing the answers with the answers provided by the software. The analysis of the acquired data reported that the matching on 18 answers (6 participants examined on three works) between classification operated by sw and by question-

naires resulted in: 9/18 occurrences of 'too low match', 5/18 occurrences of correct outcome, 4/18 occurrences of incorrect recognition. The phases relating to the training of the platform are therefore already partially underway, and the first application test of EmoDem is expected to be carried out in a short time in a museum environment. The on–site installation will allow the feasibility check to evaluate the efficiency of the concept, and to expand the dataset of images collected in different contexts than laboratory experimentation, and test the activation of the response by proposing coherent contents.

Conclusions

Although the research is in its initial stages, the tests carried out in the laboratory have highlighted the first technical critical issues, especially about the images to be used in the sampling phases of the faces. In fact, the most significant advantage of pre–compiled dataset consists of using images suitably prepared to be used during the training phases of the software; on the other side, the images acquired in a controlled research environment present a certain degree of theatricality in the emotions expressed and a lesser naturalness.
In the museum workfield phase, in order to improve the responses of the application, a second training dataset will have to be compiled with an expanded number of images with greater expressive naturalness. The major general problems we have encountered so far using AI tools are of two types. The first one is clearly represented by the skills, especially in computer programming languages, necessary to profitably conduct research and experimentation using AI applications; however, it should be noted that the issues relating to AI and machine learning systems are nowadays at the centre of public debate, and explains why in recent years the available tools and documentation have multiplied and its possible operate with these tools with an appropriate level of awareness in a multidisciplinary team. The second threat is represented by the regulatory policy and visitors privacy's protection issues, which must be defined with law criteria to allow the activation of information support only for consenting visitors. In the feasibility analysis of the project, the use of AR solutions could appear as a more effective choice than the efforts required to use an image recognition algorithm. The advantage in this last case is related to the fact that unlike the AR targets solutions, in which the references to the information contents are defined in the design phase and remain so once defined, in this mode the information is provided contextually to the reactions of the observer without there being a preordained sequence. EmoDeM tries to shift attention from the ever–increasing production of information artifacts to the adoption of technological solutions that can assist museum curators in proposing as much as possible inclusive and customized informations. The technological advancement in the field of AI therefore gives us the possibility of operating in the space between the physical object and the related digital contents, with respect to which the concept of EmoDem has been set up, designed precisely with the function of interface between the user and the digital information contents.

The editorial and scientific responsibility of the chapters is recognized to: Paola Puma for Introduction, Design of the research, Aims of the research, Conclusions; Giuseppe Nicastro for State of the art, Methodology, Expected results; both the authors Paola Puma and Giuseppe Nicastro for the figure and References.

Notes

[1] These images must be suitably prepared to be used in a Machine Learning workflow: in a first phase, the content of each single image will be divided into cells, according to a SxS grid, containing a defined number of pixels. Subsequently, the contents of any cell will be examined to identify classes of pixels with similar characteristics in areas defined by appropriate tags. The datasets thus prepared will therefore be used in the software training phases, or when further images, not belonging to the datasets used, will be analyzed to identify and classify their content.

[2] Using Machine learning solutions and computer networks in the analysis of large datasets represent practices becoming increasingly widespread. Companies like Google or Amazon offer today increasingly affordable solutions for those who intend to approach these technologies: if until a few years ago, developing an experiment in the field of machine learning implied to access to computer networks available only to specialists and researchers, today Cloud Computing has simplified the access to these resources.

[3] Among these, one of the most used is CK + [Lee, Kang 2020, pp. 15-27], an archive of images acquired in a laboratory environment and catalogued in frame sequences with which it's possible to investigate different types of faces during the gradual transition from a neutral emotional state to one of the seven emotions available (anger, disgust, sadness, happiness, amazement, contempt and fear).

[4] The Passignano abbey, located in Italy between Florence and Siena, has been documented by digital survey that used the integration of data acquisition methodologies to document the consistencies and architectural features of the complex for the purposes of knowledge and cultural enhancement. In this case, the operational scenario included the LS survey, the topographic survey, and terrestrial and aerial SFM. At the end of the research, an enhancement project was drawn up and application was developed to provide information support for visitors. BAPP application uses the Badia a Passignano complex and its works of art figures acquired during the survey campaign to train the image recognition software. By this procedure Bapp makes it possible to frame with the camera of your device any portion of the complex located along a defined visit path to access contents consistent with the object framed by the camera attaining the output deriving from the machine learning processing.

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MareXperience. AI/AR for the Recognition and Enhancement of Reality

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Abstract

The MareXperience exhibition event was held in Procida on February 22 and 23, 2019, inside an ancient cave for the shelter of fishermen's boats, 45 meters long and 8 meters wide. Inside, synchronized video projections and soundscapes were produced to create an immersive virtual environment, whose contents were inspired by the signs and fluidity of underwater life. The digital forms were generated by a Swarm Intelligence algorithm, a tool generally used to create complex kinematic structures defined by a large number of parameters. Generative design is an expressive form aimed at artistic languages and representation of dynamic contexts, which here have been integrated into a narrative process, connecting aspects of the recording of the movement of bodies in water with the principles of data visualization.

Keywords
artificial intelligence, underwater, video projections, generative design, data visualization.

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Theoretical Principles

The digital has extended the ordinary scenarios of research on the languages of the representation of reality, opening it to the complex nature of events, including it in the dynamic mechanisms of the permutation of forms to describe the variable nature of contexts; it has extended the boundaries of drawing, crossing the limits of the languages of representation and finding itself close to the matrices of thought, to its operating mechanisms before words, the text, stop their sense. The extensive fields of artificial intelligence, which now support innumerable actions and choices we make on a routine basis, are becoming more and more widespread, but solutions and tools often show the total absence of the critical processes that should support the evaluation phases, marginalised by improper technicalities in the service of the logic of profit. Yet the virtual was based in thought before taking shape as the result of technology, and in thought it defined the extensive space of the configurations of the real, of the possible, which underlie the variable nature of augmented reality. From philosophy, from Leibniz, from Deleuze and others, those coexisting paths were traced which lead to Turing and Gödel, to the principles and machines that have made possible the current state of technological research.
The concept of the virtual, as defined by Gilles Deleuze, extends the real by opening it up to dynamics of variation, the actualization of which imposes an increase in dimensions and a consistent alteration of temporal sequences [Deleuze 1997; Levy 1997]. This structure requires a complex place to give shape to the images of thought, a virtual space must be traced that includes matrices of relationships between values, meanings, expectations and emotions, as well as rooting it in the perceptive structures of reality, to facilitate the introjections of messages [Repola 2008].

The Project

The project tested a methodology for recording bodies in motion, transferring kinematic parameters into a digital simulation environment, modulating trajectories according to tension fields consistent with the compositional patterns of a virtual space overlapping the cave [Repola 2018, pp. 781-788]. The project started from research activities carried out at the Department of Humanities of the University Suor Orsola Benincasa and the Sebastiano Tusa Civic Museum of Procida, aimed at developing systems and procedures for the three–dimensional survey of seabed and submerged cultural heritage. Real numerical models offer new opportunities of spatial data management for the analysis of places and the simulation of possible scenarios and complex events. Three–dimensional data, moreover, are well adapted to be used in parametric modeling procedures for the development of immersive museums, where scenarios can change according to the needs related to the data representation.
The MareXperience project aimed at verifying a series of interrelation schemes between different digitization procedures of real contexts and solutions for data visualization in an augmented space, given by the overlapping of a segment of underwater life and an ancient cave for the shelter of fishermen's boats on the Silurenza beach on the island of Procida (fig. 1).
In the weeks preceding the event, several underwater video recording sessions were carried out in the Pizzaco and Solchiaro areas to record the movements of schools of fish. Subsequently, the acquired videos were processed in order to provide the numerical parameters necessary to generate the digital animation that composed the artistic performance. In addition, underwater soundscapes were recorded at different depths through the use of a hydrophone. The sound of the sea and its life became the track on which the three–dimensional digital sound integrated with the animations was processed. The latter allowed to place, in a virtual way, sound sources in the space increasing the perceptive levels of the visitors.
The immersive environment [Dede 2009], inside the cave, was realised thanks to a technological system built to project on the long vertical surfaces of the cave the digital video and audio processing produced in the previous phases. In particular, this system consists of a media server, specially assembled for the event, which separated and distributed, in syn-

Fig. 1. Point cloud of the cave.

chronized mode, both the video stream, to 4 ultra–short–throw video projectors, and the spatialized audio stream with 5 independent channels, to the respective 4 active acoustic speakers and the subwoofer.
The immersive installation project has exploited the spatial compression of the place, due to the oblong shape of the cave, to generate in the visitors the unexpected perceptive experience of extension of the places through the movements of the bodies beyond the limits of the long walls. The underwater soundscape, thanks to the techniques of frequency modulation and variable distribution of sound intensity on a spatial basis, supported the depth and three–dimensionality of the simulated space generating an adequate level of immersiveness of the installation.

Software Procedures

The research project, aimed at the construction of a representative protocol able to relate the user and the cultural product through a non–linear narrative logic, used technologies as a tool for the representation of aesthetic language, using machines not as a final output of representation but as a communicative vehicle. The overlapping of the levels of interaction between tools, software and communication languages, from the earliest stages of composition, anticipated the ordinary relationship between machine and man, which places one subordinate to the other. The primary cause of iteration was the generative principle of movement in nature, which recorded in a marine life interval, broken down and sequenced, has become the code of development of the kinematics of animation.
The possibility of having a large amount of data to analyze, has allowed the structuring of a transversal strategy of elaboration of the audiovisual content. For this project we used the principles of computational analysis for clustering data in a three–dimensional environment, taking as input parameters only the position attributes derived from the data extraction process. In this phase we provided the algorithms with a series of data samples chosen from the cluster categories, observed the results by manually correcting the parameters with respect to the expected aesthetic configuration and as consistent as possible with the processes of relation between real and virtual.
The Swarm Intelligence algorithm [Bonabeau, Dorigo, Theraulaz 1999] was used to generate the kinematic flows. Based on the analysis of the mass movement of fish, it is able to simulate the optimization principles of the movements of marine animals within the social behaviors during migration periods, and in strategies aimed at finding food and self–protection.
This algorithm is therefore one of the best approaches for the realization of complex kinematic structures composed of numerous agents, the considerable advantages such as high speed convergence, flexibility, fault tolerance and high accuracy, are essential and unavoidable values for the synthesis of a container capable of metabolizing the enormous amount of data collected during the previous phases.
Touchdesigner [1] was used as the synthesis software for this first test phase of the data integration method to manage the emission and control processes of particle elements in real time. The software manages these entities by means of 'SOPs' (surface operator families) which

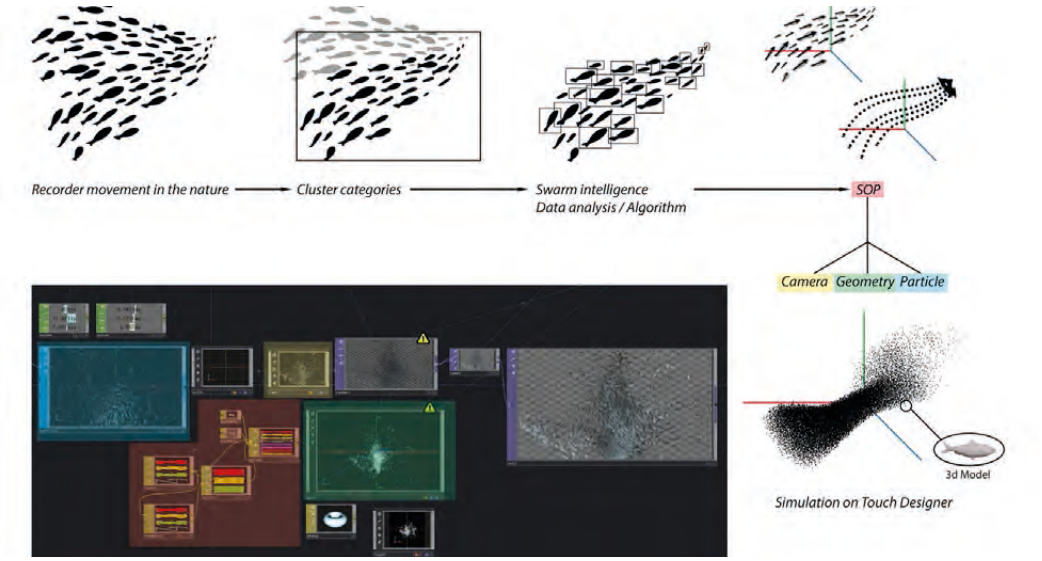

Fig. 2. Software procedures.

guarantee the parametric connection between numerical entities with motion streams. The Surface Operators family, or SOPs, is useful for all 3D operations, whether they refer to simple three–dimensional geometries, particle systems, architectural models, or 3D characters. For the optimization of rendering and thus visualization of real–time graphics processing, it should be remembered that SOP transformations occur on the CPU, which must be performed for each vertex in the geometry, taking up a lot of resources; instead, component–level transformations are applied directly to the 3D geometry, or object, as a whole and are computed on the GPU as a single operation. A single operation performed on the GPU is definitely preferable to what could be hundreds of thousands of operations performed on the CPU. The total number of points, primitives, vertices, and meshes will vary depending on which model is being processed, but the basic principle is that the more polygons/vertices there are, the more computing power and graphics memory will be required to complete the tasks. The project verified the possibility of connecting such SOPs with the Swarm Intelligence algorithm to include in the kinematic generation processes aspects of the natural movement of marine living beings. Connecting the calculation matrices to the SOP operator, the data of interest are segmented to extract numerical parameters inherent to the management of their position, rotation and scale on the three x,y,z axes. These data are linked to the Instance of the geometry containing the 3d source model of the particle system. The geometry instances in the Geometry COMP are copies of the object, which can be transformed independently. In fact, it is possible an instance for each sample of a CHOP, row of a table, pixel of an image or point of a SOP. In this way, each individual particle is a 3d model with its own levels of automatons. In this experimental design phase, the entire particle group is modified in the physical simulation parameters, specifically turbulence and wind,

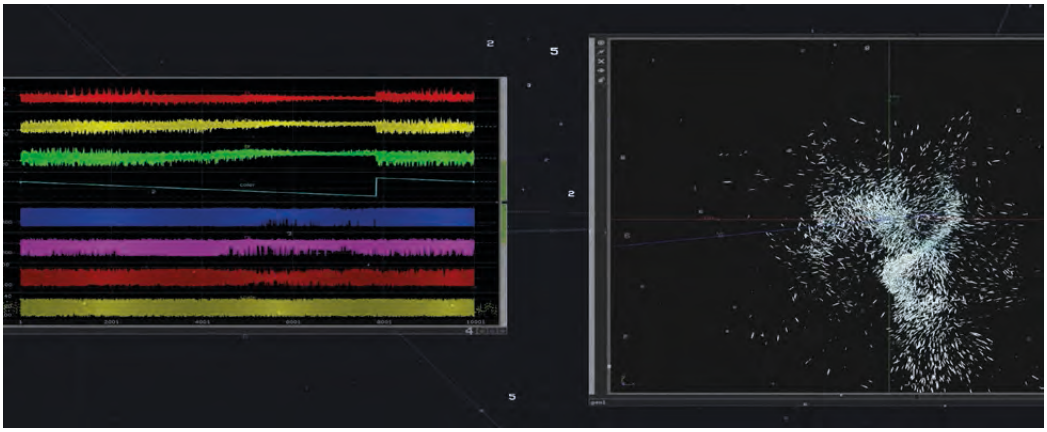

Fig. 3. Video editing phases.

by real–time audio analysis. (fig. 2) The aesthetic result obtained from the verticalization of the swarm intelligence algorithms and the vector fields obtained from the data extraction process is based on a continuous reiteration of the same data, which are influenced again at each frame, generating a swirling kinetic movement; the nodes of which the algorithm is composed generate intelligent feedback signals that mimic the social behavior of marine animals, elevating a behavioral characteristic to an aesthetic parameter.

Results

The 'sea experience' is the paradigmatic object used to build a model of representation of a dynamic reality, such as the underwater one and its fauna, through the application of fluid architectural constructs rendered through the methodologies of generative digital design. The connection of the two realities, the original and the disguised one, has obtained by means of a rigorous process of acquisition of the real data, which underwent a process of data–analysis and data–extraction to be then processed with artificial intelligence algorithms that defined the formal and expressive rules of the virtual artefact.
The analytical model of information extraction took into account the different dimensional metrics typical of a living environment, such as the underwater one, synthesized by means of the three–dimensional vector trajectories made by a school of fish, their speed of movement and the acceleration index in space. The goal was to re–generate a non–mimetic reality of the original by designing a representative complex, with different levels of reading, to stimulate the 'emotional understanding' of the context investigated, in an attempt to bring the level of knowledge to the stage of wisdom (Ackoff's model). The Exhibit design, rendered through video mapping integrated with underwater soundscapes, produced an integration between reality and a narrative component such as to stimulate the imagination, in the sense intended by Bachelard with the term rêverie [Bachelard 1973], and the synchronic perception of the different environmental qualities referable to the places of the sea and the cave.

Notes

[1] The latter is a Python programming environment in which you can visually manage user actors or operators with specific tasks that are linked together to create audiovisual patches.

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Communicating Architecture. An AR Application in Scan–to–BIM Processes

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Abstract
The paper presents the first results of an ongoing research on the benefits of implementing computational modeling in Scan–to–BIM processes for the representation of historic architecture in AR and VR application with education and communication purposes. The 3D laser scanner survey of a complex vaulted system was the starting point for the development of the research. The design of an App that optimizes the effectiveness of computational modeling concludes the workflow exporting the FBX file from Revit and then importing it directly onto the Unity real–time development platform. The study shows the feasibility of the computational approach in the application of AR and VR systems demonstrating its effectiveness thanks to the segmentation and hierarchization of the different components of the ribbed cross vault.

Keywords
interactive AR, scan–to–BIM, algorithmic modeling, 3D visualization, mobile applications.

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3D Digital Representation as Effective Communicating Framework for Cultural Heritage

Information and communication technologies (ICT) have expanded the dimensions of survey and representation models in architecture. Representation systems and graphic schematization have always been a crucial step in architecture learning process. Only due to a correct coding of the visual message, the abstract conventional 2D models of architectural drawing convey information in an immediate, rich and effective way. A successful graphic representation needs to assume a certain distance between the reality and its visual exemplification: communication acquires immediacy and quality as the degree of schematization and coding increases. In some cases, especially when there is no sharing of the codes of representation, only limited information and knowledge are available about traditional 2D graphic models. It's now widely proven as ICT can favorably impact student learning and communication of Cultural Heritage (CH), as for example in teaching–learning interaction, museum installations or virtual and augmented visits [Mortara, Catalano 2018].
New technologies such as 3D laser scanning (LiDAR) or Structure from Motion (SfM) systems constitutes a valid support to cultural heritage visual presentation and documentation in different fields of scientific research and professions. Despite the interpretation and critical representation of the massive amount of 3D data of these two systems sometimes becomes a limit, these technologies can certainly express strong potential also for communication and educational purposes. A consolidated application in architecture is certainly that of the so–called Scan–to–BIM processes aimed at generating semantically rich as–built BIMs of complex objects from 3D point clouds datasets. In our research, computational modeling allows an approach that registers BIM components with semantic information driving the design process from both 3D point clouds data and rules from historical architectural treatises. By parameterizing the modeling process, the algorithms prove to be particularly effective in the analysis and representation of object categories normally non–native in BIM libraries. The algorithm also presents the advantage of recording information on the segmentation and hierarchization of the different architectural components, with interesting and useful repercussions in AR applications. In addition to the methodological contributions, computational approach allows us to interact in the visualization of the different individual components and

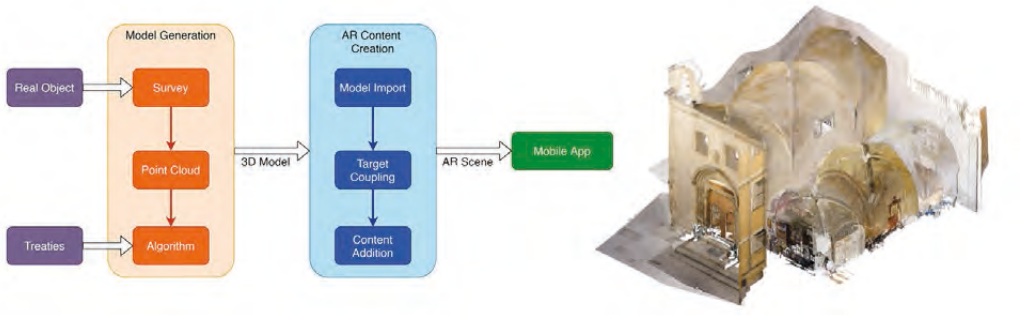

Fig. 1. Workflow from the survey to the mobile AR app (left); Point Cloud from the Laser Scanner surveys (right).

to have a range of possible relations already stored in the algorithm. The workflow was prototyped in parametric design with Visual Programming in Dynamo with Autodesk Revit and tested on a 3D point cloud of the XVI century church of Nostra Signora della Speranza in Cagliari (Italy), scanned via Leica Laser Scanner HDS 7000 (fig. 1). Starting from the 3D laser scanner survey of the entire monument, the workflow was tested by focusing attention on the main components of its complex vaulted systems, consisting of some ribbed cross vaults with pointed arches. To create smart data queries and visualizations, an App design process optimizes the potential of the approach by completing the workflow, enhancing the different visual analyzes in a very intuitive manner. AR and VR technologies provide new ways of space visualization and architecture interpretation, promoting and developing building reading skills. Thanks to the design of specific tasks aimed at users such as first–year architecture students, the App aims to optimize the reading of the anatomy of the ribbed cross vault and the 3D spatial relationships of its different architectural elements.

Algorithmic Modelling in AR Applications

For years now, the procedural generation of 3D models has played an important role in architectural production. The possibility of creating parametric processes capable of remodelling a three–dimensional element in a largely automated way allows the definition of even very complex rules for the generation of elements [Tedeschi 2014].
This type of approach is particularly interesting when dealing with elements with particularly complex geometries and at the same time constrained by the need to correspond as closely as possible to the physical models to be represented. An emblematic situation is that of Scan–to–BIM processes applied to complex historical elements, like gothic vault systems; these elements are in fact very often absent from the normal native libraries of BIM tools, and their complexity highlights the numerous constraints that BIM environments present in terms of modelling, since they are by nature information modellers and not 3D modellers [Argiolas et al. 2019].
The use of development environments based on Visual Programming Languages (VPL) has made it possible on several occasions to get around the deficits of the modelling tools of BIM environments, by releasing the modelling process from the single element, and linking it to the category of elements and therefore to their invariances [Bagnolo et al. 2019] (fig. 1). In the case of gothic vaulting systems, the hypothesis has been put forward that the definition of the geometry and curvature of the ribs is sufficient to define the entire vault [Willis 1910], to the extent that in certain geographical contexts materials and techniques do not lead to noteworthy stylistic variations [Agustín–Hernández et al. 2018].
This is possible thanks to the use of modelling algorithms developed by means of special environments such as GrassHopper for Rhinoceros or Dynamo for Autodesk Revit, both of which are now highly integrated with Revit; this makes it possible to keep the entire model creation phase within the BIM environment, significantly limiting the problems that can arise from the passage of data between software through export/import of models.
The algorithms also represent a container of information regarding the model, constituting a real metadata of it; in the algorithm, in fact, information on the geometric rules used for the realisation of the model components remains accessible, as well as how these components are assembled together and therefore, what is the hierarchical organisation of the model.
The use of augmented reality technologies is now an established practice for the communication of architectures, whether they are just designed or built, especially for the historical heritage [Spallone, Palma 2020]. It is possible to see how there is a bidirectional link between BIM models and augmented reality for the communication of architecture; if it is true that the immersiveness offered by AR plays a fundamental role in the process of 'telling the story' of architecture, it is equally true that the organisation of the elements and their classification, typical of the BIM methodology, offers a further level of deepening and understanding of the building organism.
In our specific case, notwithstanding the considerable impact of the mixed visualization of the model as a whole, the possibility of breaking down the various elements in real time and managing them autonomously in their graphic representation, offers an enormous expansion of perspectives of use. Even the mere hierarchization of the elements, in the case study based on the idea of the Uniclass 2015 classification [NBS Enterprises Ltd 2021], allows us to offer the user a reading by levels of the objects, facilitating their comprehension (fig. 2).
Another advantage can be derived from the implementation of the logic of levels of detail (LOD) of the BIM models, which lends itself well to adapting the amount of information dis-

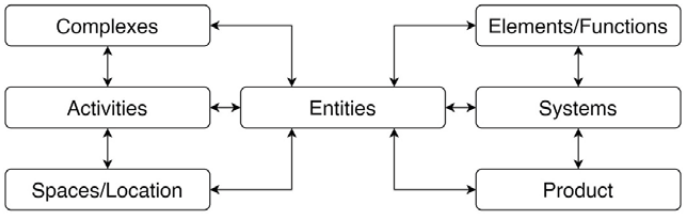

Fig. 2. Classification in Uniclass 2015.

played and its degree of precision. This translates into a differentiated visualisation according to the level of "zoom" with which the user observes the objects.
The implementation of the model of the Church of Our Lady of Hope within AR scenes was carried out using the real–time development platform Unity [Unity Technologies 2021], for the design and programming of all the interfaces and mechanics of the app. In addition to the standard modules, Vuforia [PTC 2021], a free package for the creation and management of AR cameras and targets, and PCX [Takahashi 2021] for the import of point clouds were added.

Exploration and User Interface Design

The software as configured, allows the possibility to live two main types of experiences, one in augmented reality in third person and one in virtual reality in first person.
Once the application is started and the 'start' button is pressed, the software enables the camera and the device is ready to recognize a target which can be:
• figurative, as in our case study in which the building plan was chosen;
• coded, such as QR Codes.
Once the target has been identified, the 3D mesh model appears on the screen and, at the same time, the control panel located in the lower part of the interface is enabled, allowing you to activate various functions. Hide/unhide elements (fig 3). Pressing the 'layer' button opens the sheet showing the elements according to classification system based on Uniclass 2015 of the building organization. The software allows you to turn them on and off individually with the relative box. Pressing on the text item switches instead to the detail screen, which specifically analyses the element (fig. 4). Organization in pre–packaged documents. Clicking on the square allows you to view the model according to the predetermined drawings such as plans, sections and axonometric views (fig. 4). General information. The 'i' button takes you to a tabbed screen on the historical information of the building which also recalls a photographic section. The browse button allows you to switch from augmented reality to virtual reality mode; starting from a first–person view, typical of some video games, it is possible to virtually move in the external and internal space of the building thanks to the aid of two virtual pads, one dedicated to the movement of the camera, the other to the movement in the model. In this navigation mode, thanks to on the PCX package, it is possible to switch from navigation on the polygon mesh model to the point cloud produced by the survey with the LIDAR, which allows a comparison between the two products and an even more immersive detail view.

Fig. 3. View of the AR mode with the hide/ unhide feature.

Fig. 4. View of the preset drawings mode (left), and the detail screen (right).

Conclusions

Representing the meaning embodied in complex works of architecture like vaulted systems, this approach allows a novel way to interact with the history and the theory of architecture. The combination of AR technology with the use of touch screen technology of mobile devices makes the manipulation and visualization of semantically–enriched 3D models very simple and intuitive. Interaction can take place either through QR codes or printed images like architectural plan. Improving 3D scene synthesis systems, the app allows a range of semantic queries into 3D model datasets. Strictly depending on the characteristics of the specific category of architectural components, the features included in the app prove to be very effective in the communication and representation of architecture. The research plans to continue by implementing in the 3D model all the constructive elements of the different parts of the church as well as sacred art and sacred furnishings of historical and cultural interest.

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