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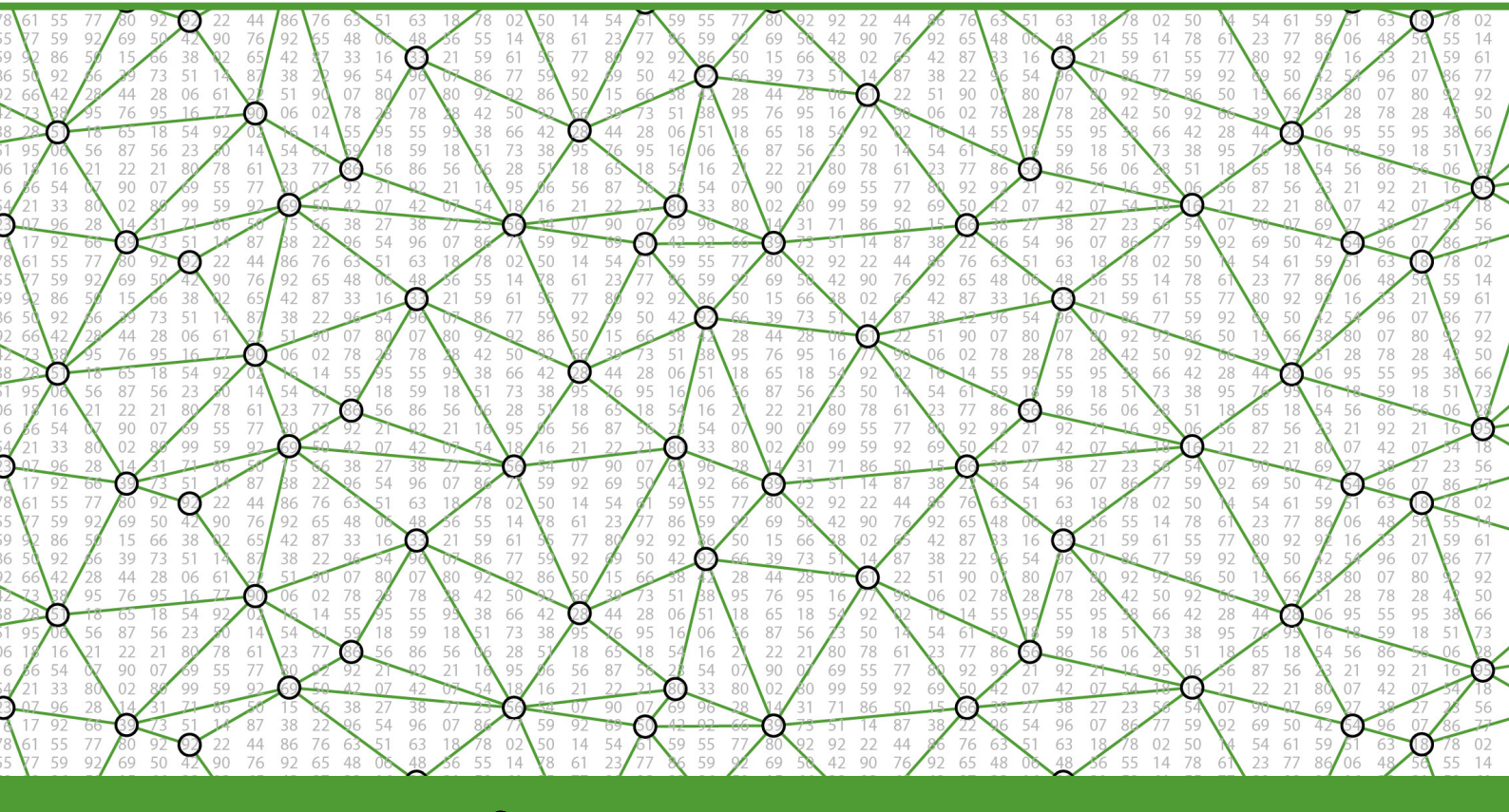
New Frontiers of AR and AI Research for Cultural Heritage and Innovative Design

edited by

Andrea Giordano

Michele Russo

Roberta Spallone



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7

Francesca Fatta
Preface

9

Andrea Giordano, Michele Russo, Roberta Spallone
Representation Challenges: Searching for New Frontiers of AR and AI Research

Keynote Lectures

21

Pilar Chías, Tomás Abad, Lucas Fernández-Trapa
AR Applications: Wayfinding at Health Centres for Disabled Users

29

Roberto D'Autilia
Cultural Heritage between Natural and Artificial Intelligence

35

Francesca Matrone
Deep Semantic Segmentation of Cultural Built Heritage Point Clouds: Current Results, Challenges and Trends

47

Camilla Pezzica
Augmented Intelligence In Built Environment Projects

55

Gabriella Caroti, Andrea Piemonte, Federico Caprioli, Marco Cisaria, Michela Belli
"Divina!" a Contemporary Statuary Installation

AR&AI Heritage Routes and Historical Sources

65

Marinella Arena, Gianluca Lax
St. Nicholas of Myra: Reconstruction of the Face between Canon and AI

73

Greta Attademo
Perspective Paintings of Naples In Augmented Reality

81

Flaminia Cavallari, Elena Ippoliti, Alessandra Meschini, Michele Russo
Augmented Street Art: a Critical Contents and Application Overview

89

Giuseppe D'Acunzio, Maddalena Bassani
The via Annia in Padua: Digital Narratives for a Roman Consular Road

97

Marco Fasolo, Laura Carlevaris, Flavia Camagni
Perspective Between Representation and AR: the Apse of the Church of St. Ignatius

105

Eric Genevois, Lorenzo Merlo, Cosimo Monteleone
Filippo Farsetti and the Dream of a Drawing Academy in Venice

113

Sara Morena, Angelo Lorusso, Caterina Gabriella Guida
AR to Rediscover Heritage: the Case Study of Salerno Defense System

121

Fabrizio Natta, Michele Ambrosio
AR for Demolished Heritage: the First Italian Parliament in Turin

129

Alessandra Pagliano
Between Memory and Innovation: Murals in AR for Urban Requalification in Anagni (SA)

137

Barbara E. A. Piga, Gabriele Stancato, Marco Boffi, Nicola Rainisio
Representation Types and Visualization Modalities in Co-Design Apps

145

Paola Puma, Giuseppe Nicastrò
Media Convergence and Museum Education in the EMODEM Project

153

Giorgio Verdiani, Pablo Rodriguez-Navarro, Ylenia Ricci, Andrea Pasquali
Fragments of Stories and Arts: Hidden and not so Hidden Stories

161

Ornella Zerlenga, Rosina Iaderosa, Marco Cataffo, Gabriele Del Vecchio, Vincenzo Cirillo
Augmented Video-Environment for Cultural Tourism

AR&AI Classification and 3D Analysis

171

Salvatore Barba, Lucas Matias Gujski, Marco Limongiello
Supervised Classification Approach for the Estimation of Degradation

179

Giorgio Buratti, Sara Conte, Michela Rossi
Proposal for a Data Visualization and Assessment System to Rebalance Landscape Quality

187

Devid Campagnolo
Point Cloud Segmentation for Scan to BIM: Review of Related Techniques

195

Valeria Croce, Sara Taddeucci, Gabriella Caroti, Andrea Piemonte, Massimiliano Martino, Marco Giorgio Bevilacqua
Semantic Mapping of Architectural Heritage via Artificial Intelligence and H-BIM

203

Giuseppe Di Gregorio, Francesca Condorelli
3DLAB SICILIA and UNESCO-VR. Models for Cultural Heritage

211

Sonia Mollica
Connection & Knowledge: from AR to AI. The Case of Sicilian Lighthouses

219
Andrea Rolando, Domenico D'Uva, Alessandro Scandiffio
Image Segmentation Procedure for Mapping Spatial Quality of Slow Routes

227
Andrea Tomalini, Edoardo Pristeri
Real-Time Identification of Artifacts: Synthetic Data for AI Model

AR&AI Museum Heritage

237
Fabrizio Agnello, Mirco Cannella, Marco Geraci
AR/VR Contextualization of the Statue of Zeus from Solunto

245
Paolo Belardi, Valeria Menchetelli, Giovanna Ramaccini, Camilla Sorignani
MAD Memory Augmented Device: a Virtual Museum of Madness

253
Massimiliano Campi, Valeria Cera, Francesco Cutugno, Antonella di Luggo, Paolo Giulierini, Marco Grazioso, Antonio Origlia, Daniela Palomba
Virtual Canova: a Digital Exhibition Across MANN and Hermitage Museums

261
Maria Grazia Cianci, Daniele Calisi, Stefano Botta, Sara Colaceci, Matteo Molinari
Virtual Reality in Future Museums

269
Fausta Fiorillo, Simone Teruggi, Cecilia Maria Bolognesi
Enhanced Interaction Experience for Holographic Visualization

277
Isabella Friso, Gabriella Liva
The Rooms of Art. The Virtual Museum as an Anticipation of Reality

285
Massimiliano Lo Turco, Andrea Tomalini, Edoardo Pristeri
IoT and BIM Interoperability: Digital Twins in Museum Collections

293
Davide Mezzino
AR and Knowledge Dissemination: the Case of the Museo Egizio

301
Margherita Pulcrano, Simona Scandurra
AR to Enhance and Raise Awareness of Inaccessible Archaeological Areas

309
Francesca Ronco, Rocco Rolli
VR, AR and Tactile Replicas for Accessible Museums. The Museum of Oriental Art in Turin

317
Alberto Sdegno, Veronica Riavis, Paola Cochelli, Mattia Comelli
Virtual and Interactive Reality in Zaha Hadid's Vitra Fire Station

325
Luca J. Senatore, Francesca Porfiri
Storytelling for Cultural Heritage: the Lucrezio Menandro's Mithraeum

333
Marco Vitali, Valerio Palma, Francesca Ronco
Promotion of the Museum of Oriental Art in Turin by AR and Digital Fabrication: Lady Yang

AR&AI Building Information Modeling and Monitoring

343
Fabrizio Banfi, Chiara Stanga
Reliability in HBIM-XR for Built Heritage Preservation and Communication Purposes

351
Rachele A. Bernardello, Paolo Borin, Annalisa Tiengo
Data Structure for Cultural Heritage. Paintings from BIM to Social Media AR

359
Daniela De Luca, Matteo Del Giudice, Anna Osello, Francesca Maria Ugliotti
Multi-Level Information Processing Systems in the Digital Twin Era

367
Elisabetta Doria, Luca Carcano, Sandro Parrinello
Object Detection Techniques Applied to UAV Photogrammetric Survey

375
Maria Linda Falcidieno, Maria Elisabetta Ruggiero, Ruggero Torti
Information and Experimentation: Custom Made Visual Languages

383
Andrea Giordano, Alberto Longhin, Andrea Momolo
Collaborative BIM-AR Workflow for Maintenance of Built Heritage

391
Valerio Palma, Roberta Spallone, Luca Capozucca, Gianpiero Lops, Giulia Cicone, Roberto Rinauro
Connecting AR and BIM: a Prototype App

399
Fabiana Raco, Marcello Balzani
Built Heritage Digital Documentation Through BIM-Blockchain Technologies

407
Colter Wehmeier, Georgios Artopoulos, Federico Mario La Russa, Cettina Santagati
Scan-To-Ar: from Reality-Capture to Participatory Design Supported by AR

AR&AI Education and Shape Representation

417
Raffaele Argiolas, Vincenzo Bagnolo, Andrea Pirinu
AR as a Tool for Teaching to Architecture Students

425
Giulia Bertola, Alessandro Capalbo, Edoardo Bruno, Michele Bonino
Architectural Maquette. From Digital Fabrication to AR Experiences

433
Michela Ceracchi, Giulia Tarei
The Renewed Existence in AR of Max Brückner's Lost Paper Polyhedra

441
Serena Fumero, Benedetta Frezzotti
Using AR Illustration to Promote Heritage Sites: a Case Study

449
Francisco M. Hidalgo-Sánchez, Gabriel Granado-Castro, Joaquín María Aguilar-Camacho, José Antonio Barrera-Vera
SurveyingGame: Gamified Virtual Environment for Surveying Training

457
Javier Fco. Raposo Grau, Mariasun Salgado de la Rosa, Belén Butragueño Díaz-Guerra, Blanca Raposo Sánchez
Artificial Intelligence. Graphical and Creative Learning Processes

Augmented Street Art: a Critical Contents and Application Overview

Flaminia Cavallari
Elena Ippoliti
Alessandra Meschini
Michele Russo

Abstract

Street art is a growing phenomenon. The frequent appearance of works, projects, and events in this area reveals its increasing social and cultural role worldwide. The chance of digitizing art represents a benefit to defining cultural paths on the territory, providing an additional tool to understand and interpret it. Street art is characterized by peculiar aspects that make it unique in the artistic panorama. The democratization of contents and the physical decay of the work are two pillars. Any digitalization and communication project should consider them carefully, proposing a knowledge model respectful of the art. Augmented Reality (AR) is a representation tool that leads to achieving that delicate balance between the real and the digital, enhancing the specificities of both. The authors start from the experimentation about artwork digitalization, connecting image deterioration with image recognition. Besides, they show some possible applications in Rome through a critical analysis of the domain, opening some future multidisciplinary scenarios.

Keywords

street art, impermanence, marker tracking, content connection.



Introduction

Street art, considered as a free graphic representation of artistic subjects on vertical or horizontal surfaces, is experiencing a moment of a global renaissance. These representations, which characterize the urban scenes, belong to everyone: creators, citizens, tourists, critics. It is an art without boundaries, free from museum routes but limited in protection and affiliation [Balocchini 2012]. Street art has different goals. On the one hand, it wants to enhance degraded urban areas and architectural structures, introducing new signs of cultural rebirth. On the other hand, it radicalizes the memory of places [Ciotta 2012]. The increasing number of artists confirms the growth of this phenomenon on a national scale, promoting events such as *Super Walls* [1] or *CHEAP* [2]. Besides, there are many events and projects worldwide, like *SHINE Mural Festival* (Florida), *Upfest* (Bristol), *Street Art Fest* (Grenoble), *Afri-cans Street Art Fest* (Kampala), *HK walls* (Hong Kong), *MURAL Festival* (Montreal) and *Brisbane Street Art Festival* (Brisbane). Different international projects aimed to connect artistic works within urban fabrics in Madrid [3], Barcelona [4], Lisbon [Guimarães et al. 2016, pp. 3654-3657], Glasgow [5], Vienna [6], USA [7]. Instead, Street Art shows a slow development in areas with strict regulations, like the movement *Streets are yours* promoted in Japan. In China the Street Art was applied on the walls of many schools in 2016 to promote the return to class in disadvantaged areas through the project *Back to school China*. Finally, the foundation of extraterritorial associations that promote street art linked to specific global issues, such as slavery and child labor, is growing (i.e., <https://streetartmankind.org>). The topic's relevance has led to the creation of journals devoted to street art, such as the *Street Art & Urban Creativity Scientific Journal (SAUC)*, thematic journal issues [8], or specific workshops [Casimiro 2019, pp. 1-2].

In a global communication framed by massive use of images and videos, the growth of this artistic movement may benefit from these digital channels. The link between artworks and descriptive or multimedia content can significantly improve street art understanding, valorizing the presence in the territory. Augmented Reality (AR) is a tool to read "beyond the visible", providing a multigenerational stimulus that brings different audiences closer to Street Art, proposing new cultural paths. A cultural approach compliant with the street art principles and its contents requires answering the following questions:

- Can the digitization process be respectful of a street artwork?
- What is the balance between permanent digital data and temporary art?
- Could the interest in applying AR tool overcome the attraction in the real artwork?

The authors try to answer by proposing a critical analysis of the main characteristics of street art and the pros and cons of AR in the domain.

Main Street Art Features

Urban art can be considered a wide container within multiple artistic currents converge, from graffiti to street art, with specific materials, communication, and representation [Arnaldi 2014]. Often street art describes contemporary subjects or political themes, provoking people and creating a deep relationship with public spaces and inhabitants. Some features are relevant for understanding the street art essence establishing a respectful relationship. The "democratization" of contents and communication is the first one. Street art has become a socio-cultural phenomenon defined by dynamic connotations with no precise edges. For these reasons, the artistic subjects expand the audience to all ages and cultural backgrounds. The flourishing of many events organized by cultural associations in collaboration with public institutions worldwide exemplifies this trend, leading the art into a more framed flow. At a national scale, the Cultural Association *MURo* [9] promotes festivals and urban art projects, fostering the idea of a diffuse museum of Urban Art in Rome. In the same district, the social projects *Big City Life* (2015) and *Moltitudini – Big City Life* (2018) [10] allowed to requalify some buildings in Via di Tor Marancia and Tor Bella Monaca. Another projects are *Diciamo Insieme Grazie* and *Dominio Pubblico – MILLENNIALS A(r)T WORK – MA(r)T*; the first

left a testimony on Covid-19 emergency, the second bring up young people contact the urban fabric and contemporary art. Despite these examples, several artists want to preserve a connotation of illegal activity and free experimentation, working in degraded urban areas or abandoned buildings. At last, art democratization refers to the urban transformations and human sensory limitations that can neglect art accessibility.

The concept of temporary street art, named "impermanence" [Meschini 2020, pp. 1-22], is a second pillar. Artists are aware of the limited durability of their works, due to the materials and techniques used or to the "illegal act" connotation that makes them liable to removal. Artwork can be subjected to tears, vandalism, removals, thefts, and natural deterioration, exploiting the incisiveness of the image through its dissolution. Some techniques are devoted to speed the realization and the communicative impact. They are often ephemeral results that become a heritage imprinted in the collective memory. This latter is conceived in a participatory form to relate people and places through installations designed to be destroyed, torn, disassembled, and taken away in fragments as memories. They are subjects to people's good decisions, bad intentions and weather events, determining all their transformation during the time. The disappointment for the limited lifetime arises from external people, while the artists claim its key role in the art. Some other artists are searching for a new meaning of permanence in terms of techniques experimentation, assigning a function of environmental sustainability. Finally, there are some examples of restoration of artworks, removing graffiti and tags that limit the art reading.

Digital Street Art

The physical and digital worlds, framed in the street art domain, highlight a complex relationship with apparently antithetical characteristics. The digitization of artworks improves their visibility in the territory, facilitating their search, accessibility, and classification [Novak 2015, pp. 13-25] and digitally freezing their state of art [Rodriguez-Navarro et al. 2020, pp. 1-22]. Nowadays few national and international databases collect the artist's works and relative characteristics. An example is the *Street Art Cities platform* [11], which catalogs and collects many street artworks worldwide, linked to a geographical map. In Rome, there are similar projects, such as the *GRAArt project* [12], conceived by David Diavù Vecchiato and MURo association. It traces the history and myth of Rome on the walls of the *Grande Raccordo Anulare*, mending the cultural gap between the monumental historical center and the suburbs [AA.VV. 2020]. A second project is *STREETART ROMA* (Atribune) which allows finding the artworks in the Capital area within mobile systems. The project has a broad audience offering geo-data integrated with the text, images, and videos. Finally, there are some examples devoted to single artists. *Banksy Street Art Treasure Map* is a free app for IOS mobile systems dedicated to Banksy's works worldwide. *Millo's official website* presents a map for exploring and viewing his works. In this framework, artworks digitalization and geo-localization simplify the construction of virtual itineraries, strengthening different cultural and thematic connections. It also allows freezing operas, fixing their conservation condition in a digital trace. However these pros, the digital replica lacks the physical relationships with its territory.



Fig. 1. Sequence of works that present the need for supplementary information that deepens the citation, the generative or constructive principle. a) The Deposition of Truth (Sirante); b) Piekary (Sten&Lex); c) Punto di fuga (JR).

The digitization can provide additional contents (2D/3D iconic-graphic info, static or animated data) simplifying the understanding of the representative mechanisms behind the artwork without interfering with a direct reading. Firstly, it can help reading the connection between different operas by descriptive information and links to the artworks, such as Sirante's *The Deposition of Truth*, based on *The Deposition from the Cross* by the painter Rogier van der Weyden. A second application may explain particular techniques to achieve specific results, like Sten&Lex operas. According to black and white lines, they work with the stencil poster technique based on very fragile paper matrices. The artwork generates different perceptions according to the viewing distance, recalling the world of Optical Art. So, the artwork can be better explained deepening the optics principles. Finally, it can be crucial to use digital data to explain the works' geometric construction by referring to perspective principles. An example is JR's perspective anamorphosis of *Punto di fuga* artwork, a large-scale poster art (Fig. 1).

A solution that may preserve the characteristics of the works and provides integrative digital content is represented by Augmented Reality. It is a tool in which real and digital converge, allowing to explore and perceive information not contained or not immediately/visually perceivable in reality [Geroimenko 2014]. However, the interest in applying this tool may overcome the attraction in the real artwork. For this reason, it is appropriate to plan a critical design process that identifies the most suitable content, improving the art perception without replacing its direct reading and the relationship with the environment.

AR for Street Art

The augmented reality process is defined by steps which can be declined to multiple application areas [Russo 2021]. Content democratization, art impermanence, and image recognition are crucial in AR planning for street art applications. Urban art belongs to everyone, so democratization refers to the user's domain, consistent with the purpose of the work. The AR users must range from children to the elderly. Accessibility is, therefore, a critical prerequisite, which is reflected in the type of device, the AR applications, the virtual interaction, and the content complexity. Smartphones and open-access applications are considered a suitable solution. The level of interaction must be engaging but straightforward, enlarging to a broad audience. Finally, it is appropriate to avoid both trivial and complex contents, by promoting accessibility and meeting interests for multi-generational people. The content linked to the work is critical since it defines the relationship with the work and the cultural growth of the user. First, it must be consistent with the type of work, offering insights of a geometric-constructive nature, transversal reading, descriptive contents, or inspiration suggestions. Besides, the content visualization should neither replace nor hide the work, highlighting the opera, its relation with the context, feeding a new experience and interaction. The content may range from texts to photos, from drawings to interpretative 2D/3D models and videos. Data simplification and description must consider the audience, the work of art, the user experience, and the level of interaction (Fig. 2). Besides the content, a second AR pillar concerns art recognition techniques. The geolocalization (markerless mode) makes it easy to build itineraries, simplifying the recognition of artworks that present low accessibility. On the contrary, it can lead to a possible mismatch in the artwork recognition and it is invariant to the urban and artwork transformations, so it is not suitable to preserve the link between art, its transformation and the environment. Marker recognition, expressed through coded images or 2D/3D geometries, creates a direct relationship with the subject, offering a more consistent solution with art impermanence, the context of insertion, and fruition (Fig. 2). This approach can show some limitations in itineraries construction and artwork fruition if they are located in confined places. Several AR projects for street art communication and promotion have been proposed in recent years. MAUA [13] is an open-air museum project spread over several cities, allowing the transformation of the works in a participatory way. This project has ignited the interest in AR street art, even if it suggests an overlap of graphic reinterpretations that only par-

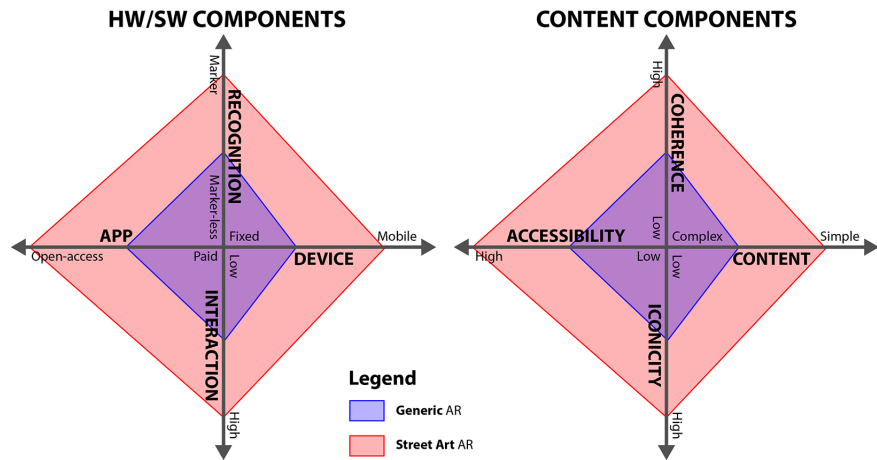


Fig. 2. Star diagram with main hardware/software and content components related to AR for street art.

tially preserve the reading of the original work. Besides, the desire to connect multimedia content to artworks with AR, improving storytelling and expanding their fruition, is a theme felt by several artists. An example is the free app *JR:murals*, which allows interacting with some artworks and accessing audio-video content.

Temporary AR Test

Based on the observations made so far, the authors analyze the image recognition topic and suggest the association of suitable content to the artwork. All AR experiments have been carried out in Unity and Vuforia platforms. We started from the logical assertion: the recognition capacity of the camera should lower with the decreases in the artwork readability. So, the art impermanence would be respected, linking the digital content to the artwork readability. Two open aspects converge on this point, justifying an experimental path. The first regards the gradual physical decay of artworks, if not caused by anthropic interventions, compared with a sudden stop of the digital system. The second aspect refers to identifying when the digital system can no longer recognize the artwork. Although not verifying all the variables involved in the process (camera characteristics, environmental conditions, graphic characteristics of the work, viewing distance), a first experiment was planned to test this relation. The target image used is an orthophoto of the artwork *Jeeg Robot* by Solo, created within the project Big City Life – Moltitudini 2018. Starting from this image, the time



Fig. 3. Scheme of the experimentation: on the left are the different types of targets that simulate the transformation of the artwork in time; on the right, the scheme of taking in plan and elevation.

effect has been digitally simulated. The variation of color saturation is intended to simulate the color lack. The change of transparency corresponded to the uniform leaching effect. The progressive loss of reading areas simulated the wall damages, the presence of overlapping elements or artwork lacks. The different prints have been positioned on the same wall, unifying the lighting conditions and avoiding the effect of backlighting given by display projection. The smartphone's camera (A3 Samsung) was positioned at a distance of 1 meter from the target images, with the optical axis perpendicular to the wall (Fig. 3). In this passage, the image recognition failed for two prints: the one with 75% transparency and the one with 80% of area reduction. The number of features still present in the remaining part affected the latter result, stressing the ratio between features and preserved area. Conversely, the color desaturation did not make any difference in image recognition. A second test was led 5 meters far from the wall, still with a perpendicular axis. Such distance allowed framing the different classes of variables simultaneously. The experiment showed a reading priority of the images that contain more features. The color does not intervene in this priority, considering the image with a different saturation value at the same level. In the third and last test, the camera was positioned oblique to the wall. This experiment identified the priority between similar images in the distance criteria, choosing the closer image.

AR and Street Art in Rome

Based on the experiences, an AR application has been tested on three different case studies in Rome with the figures of Anna Magnani (Fig. 4). The first example is a large-scale mural on a flat surface, created using the paint mural technique by Lucamaleonte. The work depicts three different faces of the actress with two yellow-red roses, recalling the city of Rome, the Roma team, and the film *La rosa tatuata* (1956), directed by Daniel Mann. For these reasons, it was deemed appropriate to link a film clip to strengthen the cinema connection. The second case study is a stencil painting by Diavù made on a series of parallel surfaces belonging to a staircase. The work is titled *Anna Magnani – La Diva*, which does not reference a specific film. For this reason, the example lends itself to the connection with an explanatory content of the representative model, underlying the realization of the work by anamorphosis of decomposition. In this case, two additional elements do not favor artwork recognition. The anamorphosis requires seeing the artwork from a specific point of view and extracting the correct representation. It works both for the target acquisition and for the AR application. Besides, the multiple planes of the representation do not fit well with the camera's focal plane and the normal of the planes to fix the digital content. So, the recognition process depends on the point of view, the number of projection surfaces and the features contained in each plane (Fig. 5). The third and final case is a small flat surface affiches using the stencil poster technique. The work is by Lediesis, part of a series of stencil posters whose meaning is more linked to the women and their capacities. Therefore, Anna Magnani's image represents the universe of strong women. So, it was considered more consistent to link the work to an interview with the Lediesis, explaining the general meaning in the use of female figures.

The experimentation revealed several bottlenecks in the application process. In the case study of Lucamaleonte, a determining factor was sunlight, which illuminates the entire surface at certain times of the day. This boundary condition has obliged to balance the AR videos transparency better, preserving the work's legibility and AR content (Fig. 6). Diavù's staircase showed the importance of identifying decomposition's correct vanishing point of the anamorphosis. It determines the correct legibility of the AR. The presence of numerous planes makes identifying the image by the camera complicated, simplified by using the central part of the image as a target (Fig. 6). At the same time, the presence of steps in the video transparent background confuses the visualization of the content, preferring a non-transparent visualization. Lediesis's artwork presented an obstacle that prevents the work from being read in its entirety. The contents have been presented without transparency (Fig. 6), while the transition from nadiral to tangential makes the AR unstable.

Fig. 4. Case studies analysed in the experimentation: a) Anna Magnani in Tiburtino III (Lucamaleonte), Anna Magnani. La Diva e la donna in Nuovo Mercato Andrea Doria (Diavù), Anna Magnani in Trastevere (Lediesis).



Fig. 5. Photographed staircase (left), geometric-perspective scheme with vanishing point and projection of the plane onto the steps (centre), anamorphosis reprojected in true form (right).

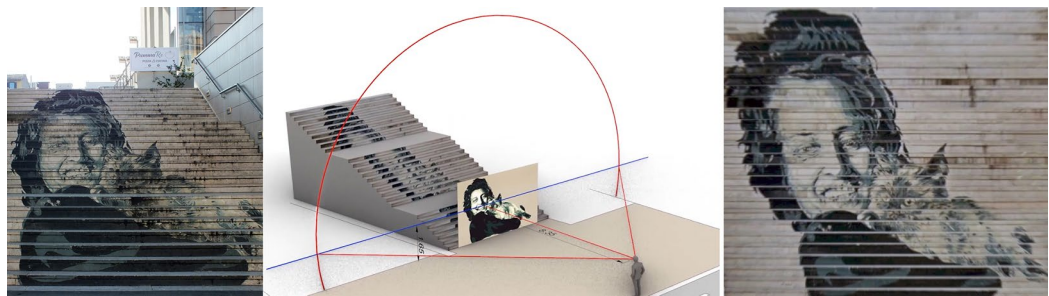
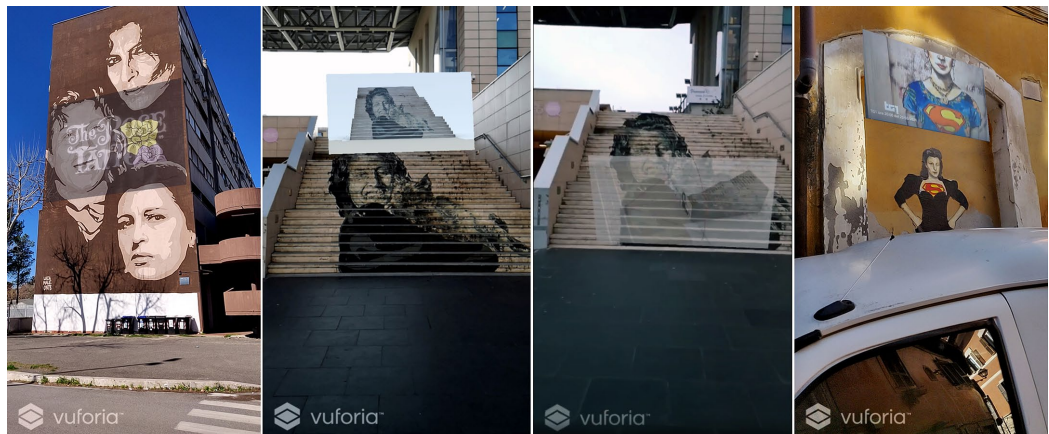


Fig. 6. Experiments with AR in the three case studies with video in transparency (left), animation (centre) and top video (right) within Unity and Vuforia environment.



Conclusions

The proposed research focuses on AR to enhance and understand Street Art, suggesting a respectful digital-real relationship with the artist. In particular, it is critical to keep the democratic content and the possibility of non-durability of the work, suggesting a consistent interaction in a multi-platform open-source application. Besides, the image recognition approach establishes a direct relationship with the physical artwork, setting the digital function according to the art conservation. This passage preserves the direct link between the work and the digital content, with regard to the durability of the work. The art recognition highlights some bottlenecks, given by the applied techniques, the external light conditions and the shape of which the artwork is represented. For example, in the anamorphosis recognition requires solving both the reverse perspective, looking for the preferred point of view and the mismatch in the recognition by the camera. This problem may change when dealing with works projected onto different (e.g. cylindrical) and complex surfaces. Finally, the AR content must enhance the work without hiding it, choosing the most suitable textual, multimedia, or 3D data. The content's accessibility is connected to the democratization aspect, ranging over the levels of iconicity and the target audience. AR in urban art can substantially contribute to fueling the growth of this domain if designed according to a priority of content consistent with street art. The experiment in the paper suggests a possible critical approach to the problem. Besides, the topic traces a research domain defined by a multidisciplinary connotation, opening new research scenarios.

Attributions

The authors all contributed to the development of the research. In the writing of the article, the authorial attribution is as follows: F.C. was responsible for the paragraph "Temporary AR test," E. I. wrote the introduction, A.M. was responsible for writing the paragraphs "Main street art features" and "Digital street art," and finally M.R. wrote the paragraph "AR for Street Art" and the conclusion.

Notes

- [1] <https://www.biennalestreetart.com/>
[2] <https://www.cheapfestival.it/>
[3] <http://madridstreetartproject.com/>
[4] <https://www.streetartbcn.com/>
[5] <https://www.citycentremuraltrail.co.uk/>
[6] <https://www.startnext.com/viennamurals>
[7] <https://streetartunitedstates.com/>
[8] <http://disegnarecon.univaq.it/ojs/index.php/disegnarecon/issue/view/27>
[9] <http://muromuseum.blogspot.com/>
[10] <http://www.bigcitylife.it/>
[11] <https://streetartcities.com>
[12] <http://www.graart.it/>
[13] <https://mauamuseum.com/>

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