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An itinerary for experiencing and understanding the pictorial apparatuses in the SS. Trinità dei Monti monastery in Rome

Un percorso fruitivo e conoscitivo degli apparati pittorici del Convento della SS. Trinità dei Monti a Roma

This article describes the process of designing an itinerary for the fruition of the theoretical contents belonging to the XVII Century anamorphic pictorial works within the the SS. Trinità dei Monti monastery in Rome. By means of new technologies for virtual and augmented reality, we propose two systems for educating a wide audience to the cultural heritage, capable of promoting the complexity of the Baroque projective geometry principles through a performance rich in contents. The working phases and the results, here summarized, can be considered as a prototypic case study within the wide context of the Digital Heritage studies: it underlines how the effectiveness of the two devices designed and partly built, a smartphone App and a Video Mapping show, is strictly related to a cultural awareness which is essential to reveal the depth of the contents by means of the most suitable communication strategies.

Il contributo propone un percorso fruitivo dei contenuti teorici connaturati alle opere pittoriche seicentesche in anamorfosi conservate nel convento della SS. Trinità dei Monti a Roma. Attraverso le nuove tecnologie proprie della realtà virtuale e aumentata viene proposta una soluzione divulgativa del patrimonio culturale, in grado di spettacolarizzare e allo stesso tempo valorizzare la complessità degli assunti della geometria proiettiva di epoca barocca. Quanto esposto, attraverso le sue fasi realizzative, offre un caso prototipico nell'ampio contesto del Digital Heritage, sottolineando come l'efficacia dei due dispositivi progettati e in parte realizzati, un'App per smartphone e un progetto di Video Mapping, sia strettamente connessa a una consapevolezza culturale in grado di svelare la profondità dei contenuti attraverso idonee strategie comunicative.

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parole chiave: *Trinità dei Monti, Digital Heritage, Video Mapping, Realtà Aumentata.*

1. THE VIRTUAL MUSEUM: EXPERIENTIAL VISIT AND IMMERSIVE FRUITION

With the advent of the digital systems, the field of cultural heritage safeguard and preservation underwent a radical transformation of its methodological and operative systems by means of new backing technologies that allow to analyse, survey and build models, and that are becoming more and more refined and complex. The data gathered and produced by the use of these technologies are tools both useful for monitoring the decay and supporting the optimization of the restoring, and functional to the divulgation and the musealization (also virtual) of the cultural heritage. In fact, today, one of the chief interests of the digital heritage field is that of working on multimedia technologies to define procedures fit to innovate the communicative possibilities of contents. For example, during the Fête des lumières in Lyon every corner of the town is redrawn by light projected on monuments, bridges and streets: events like this show how contemporary information technologies can enhance the artistic and cultural heritage by capturing the interest of a wide audience and, at the same time, increasing the collective awareness about its value [1]. This kind of events, in fact, is mostly useful when the show is not only built 'for fun', but instead reveals and gives value to the historical and theoretical substratum of an artefact, as in the case study presented in this article. The Festival of Lights is chosen as an example because it cleverly keeps together a local festival of ancient origins with the local administration's will to promote and enhance the artistic heritage of the town for a very wide and culturally heterogeneous audience [2].

2. THE CHOICE OF THE CASE STUDY

Following the tendencies quoted above and chosen as virtuous examples for their proved efficiency, a pilot scheme have been set up for evaluating the benefits – in terms of cultural, touristic, educational and economic incomes – coming from the application of an analogous fruition strategy. For this purpose, it has been necessary to find a fitting case study that presented features functional to test the systems in exam. Thus we chose the SS. Trinità dei Monti monastery in Rome, where there are artistic and scientific works characterized by an immaterial depth of information [3] which is as dense as complex, very difficult to understand and at the same time forming a perfect synthesis of the several criticalities we wanted to take into account. It must be also added that the monastery is subject to a reduced touristic fruition, despite its very central and excellent position in Rome.

The convent, established by the Minim Friars' order in the XV Century, includes some pictorial apparatuses attributed to Emmanuel Maignan (the anamorphic portrait of St. Francis of Paola, founder of the order, 1639; a catoptric sundial, 1637, whose lines are visible on the vaulted surface of the Northern corridor at the first floor of the cloister) and to Jean François Niceron (the anamorphic portrait of St. John the Evangelist in the act of writing the Apocalypse in Patmos, 1639) (Fig. 1). There can be seen, besides, two works by the Jesuit father Andrea Pozzo who, towards the end of the XVII Century, painted the representation of the Marriage at Cana in the big room of the refectory, and the Glory of St. Francis of Paola on the ceiling of the library at the upper floor, just above the apse of the church. These works, testifying the early Baroque taste for wonder, come from the deep interest of their authors for projective geometry and the extreme application of its laws, in order to obtain representations – alluding to the three dimensions – of great immersive and theatrical impact upon the observer. The anamorphic paintings and the quadrature of Trinità dei Monti are in fact an outcome of the studies on optics, thus embodying experiments on visual perception. The decades between the Minim friars' painting and Pozzo's testify, beyond a common exegetic horizon, an increasing attention towards the immersive 'spectacularization' of the work, related to the already codified

Fig. 1. Perspectival section of the first floor of the SS. Trinità dei Monti Cloister. In the left and right corridors are seen respectively the paintings of St. Francis of Paola and St. John the Evangelist. In the central part, the catoptric sundial.

geometric-projective techniques. These are among the reasons why these spaces, considered altogether and belonging to the same architectural complex, can be appointed as the ideal case study for employing communication technologies based upon virtual and augmented reality, particularly fit to reveal – also to non experts – the complexity of the theoretical contents, by means of 'spectacular' events.

3. THE STRATEGY: IMMERSIVITY, COLLECTIVE FRUITION, INDIVIDUAL FRUITION

The second phase focused on the definition of the theoretical and procedural framework upon which the design phase has been grounded. The general goals of the research has been combined with collateral but nonetheless binding aspects: the complex layering of information, the necessity to face a financially critical context, the presence of both business and academic interests and especially the choice of employing technologies that are often massively deployed without a coherent critical approach.

The design phase has been sketched out starting from a thematic pair: on one side it has been taken into account the concept of 'intangible heritage' which, by focusing on a more impalpable dimension of the heritage – i.e. the invisible information which any artefact conveys per se, beyond the mere material dimension – conditioned all of the following critic, communication and media choices, favouring a process of clarification, disclosing and 'assisted narration' of this intrinsic component. On the other side, instead, much importance has been given to fruition practices and their peculiarities, and in parallel to building relations between them and the so-called Immersive Technologies, not only by considering the criticalities of the systems currently in use but especially by identifying truly innovative solutions, capable of employing the performative and experiential features to meet the needs both of the final users and of the experienced heritage [5].

By crossing the two approaches and applying them to the case study and its specific criticalities, a project aiming at enhancing the status quo has been developed through the selection of the most fitting strategies and the consequent definition of the most adequate technological solutions. A double fruition level has been chosen for this specific case, to offer a diversified approach both in terms of involvement and in relation to the different typologies of information that each channel could transmit. Therefore, the first consists of a 'collective' solution for a wider audience, based on 3DMapping with projections on the inner façades of the cloister, which implies the planning of a cycle of audio-visual performances in a fixed schedule. The second instead relies on a more 'individual' and personalized channel, with an App for mobile devices in Augmented Reality.

Fig. 2. Perspective view of the SS. Trinità dei Monti Cloister point cloud.

4. WORKFLOW: DEVELOPING THE PROJECT

The guidelines which have been defined during the initial phase have been later taken into a productive process that gave substance to the theoretical premises, studied their effective fruition and didactic potentialities, and finally translated them into the prototype synthetically presented in this contribution. The development of the contents and the following prototyping and testing phases thus underwent two different paths, according to the different workflow required by each strategy. The only common phase took place the beginning, when the concept has been defined and a palimpsest of archival data has been built according to a careful interpretation of a big amount of documented and critical information. Tools coming from cinematography (for the 3DMapping) and from web design and gaming (for the App), together with a constant effort devoted to translating the intangible components of the artefact into a coherently narrative and scientifically rigorous system, led to the production of operative documents – starting from graphic and textual storyboards – that formed the bases to build both the mapped performance and the inner architecture of the App. The two narrative paths have been planned to guarantee the most efficient and the denser transmission of information from the object to the visitor.

The 3DMapping approach is scenic, as the facades of the cloister are considered as a theatrical setting. The App instead favours the detail, by gathering the data (symbolic elements, traces of historical events and of restorations, geometric features, etc.) that work better with a closer and autonomous fruition. Independently from the communicative immediacy, which was a requisite for both the approaches, it must be recognized that the 3DMapping offered the greatest freedom of expression, according to the performative nature typical of mapped projections. The narration has been split into two different cycles: the first (circa 2 minutes of duration) is dedicated to the material skin of the building, with a series of luministic and architectural effects chosen to enhance the volumes. Therefore, at the introduction there is a scene that aims at immersing the audience in the proper receptive condition, favoured by the gradual obscuring of the cloister until the façade is in complete darkness. After the black, the mapped effects appear in the following order: the wireframe redrawing of the main geometries; the reconstruction of the colour and shadow effects generated by solar light during the different phases of the day; and a series of pure luministic simulations, inspired by show business strategies – followspots, stage lights, etc. – and by light design and architectural illumination. The second set is dedicated to the paintings in the corridors and their representational and historical aspects: the façade disappears in darkness and the simulation of the opening of the walls reveals a representation of what is kept inside at the first floor. This 'opening' is followed by scenes describing how the paintings have been made by their authors. Projected on the walls it can be seen a simulation of the layering of the plaster, of the placing of the ectypus, of the tracing of the sketch, the phases of application of colours and the technical solutions that have been employed to obtain the anamorphic deformations (grid of wires and light source methods). The last scene of this sequence reinforces the climax designed for the previous ones: the representation of the whole corridor rotates around its own barycentre, embodying the illusion of a whole block suspended in the void and temporary allowing the audience to observe the anamorphic painting – until this moment displayed frontally – from the rectifying point of view [6].

5. THE 3DMAPPING PERFORMANCE

As regards the 3DMapping, the work have been organized according to the typical workflow for this kind of product, and the usual macro-phases and general procedures have been adapted to the specific case [7]. A careful survey has been the first step to start organizing the technical staging project: the number or required projectors, the positioning of supporting structures, the light cones and other technical aspects are in fact the first concerns when dealing with mapped projections, not only because they condition the technical feasibility of the project, but also because they are the most expensive features. During the preparatory visit, a first survey campaign has been conducted on the buildings and the artworks, from which a 3D digital clone of almost all the monastery have been built, shaping a rigorous scientific reference for the following phases. The survey gathered information in two different moments: the first campaign employed mostly highly accurate laser scanning technologies, in order to give shape to the volumetric, dimensional and partly chromatic features of the façade of the church, of the cloister and of the painted corridors at the first floor. The many point clouds gathered, joined together, brought to a 3D model made of points, each with its RGB value, referenced according to a filtered and levelled scan. The maximum error determined after the alignment (which is the distance between the position of the same vertex in different point clouds) is below 5mm, further reduced under 2mm after fitting algorithms had automatically searched for couples of homologous points in the overlapping areas of two different acquisitions. The clouds, optimized and organized in a single local reference system, form a 3D point model (Fig. 2) of circa 1.485.242.000 units. This phase of the survey lasted on site for only two full days,

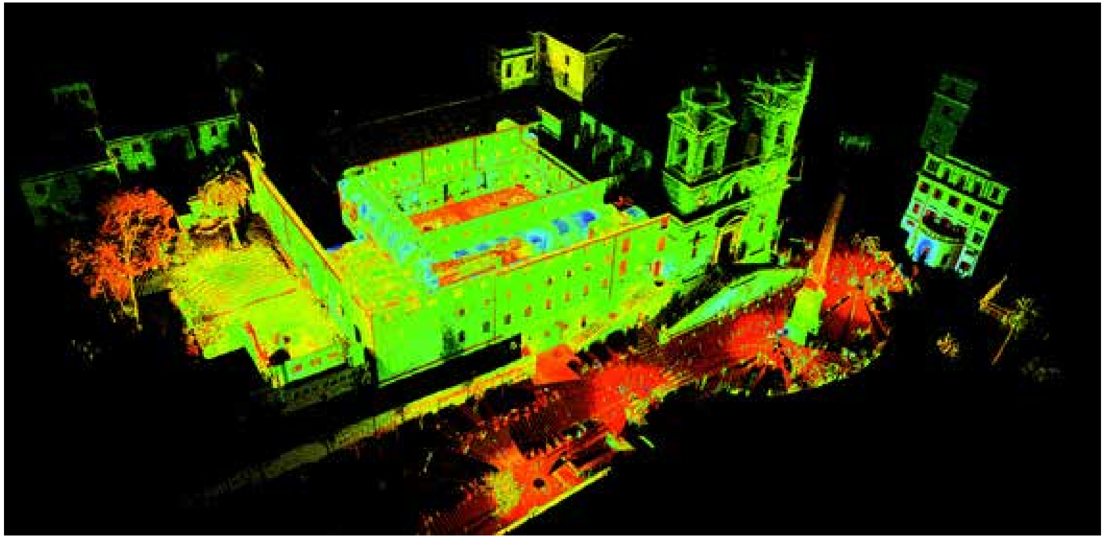


Fig. 3. Point cloud of the complex of corridors located on the first floor of the monastery.

but it was preceded by a long survey plan that allowed to establish in advance the different positions of the scanners, according to the configuration of the different spaces (Fig. 3).
The second campaign focused especially on the refectory and on the library, both frescoed by Andrea Pozzo: they are not directly part of the fruition enhancement initiative here described, but they can be potentially joined in a long term project. Differently from the first campaign, this one has been based on multi-stereo digital photogrammetry techniques (Fig. 4), allowing also to test some of their advantages [8]. This campaign, belonging also to another research project [9], used in fact a survey methodology based on photographic hardware that later proved to be very useful for the case studies discussed here, because it also implemented and refined the results previously obtained for the other objects of interest. The whole monastery has been considered as a big workshop both for testing the survey methodologies on spaces of different dimensions and shapes, and for studying some of the most advanced results of the XVII Century science and art of representation, here embodied by works by Niçeron, Maignan, Pozzo and by the later Ruin Room by Charles-Louis Clérisseau. The hardware set up was composed of a full frame digital reflex camera, four calibrated flashlights and a motorized panoramic head for spherical giga-photography: this allowed to shoot in ultra-high resolution [10] photos to be processed via multi-stereo matching software as well as spherical panoramas, with even denser data information – useful for further researches on the smallest details [11].
Starting from these considerations, it must be underlined that the survey operations have been fundamental for every following phase. They've been initially used to process data and build a 3D mathematical model of the complex, obtained through reverse engineering operations (Fig. 5) from the final point cloud: during this phase, besides the common questions typical of converting a point cloud into a model, particular attention has been required by projective necessities, such as for the dense fragmentation of detailed elements (columns, windows, cornices, …) belonging to the façade hosting the projection, necessary to make easier and more accurate the application of effects and

Fig. 4. A phase of the survey of the refectory painted by Andrea Pozzo.

animations (each element should have the possibility of being handled autonomously) as well as for allowing a better control of volumes and of the punctual overlapping of real and digital (projected) architectural elements.
After the model, it was possible to build mapped contents. The 'twin' technologies employed are motion graphic 2D and 3D, but first of all a storyboard had been developed and defined, from the general stylistic definition of the event to the matching of every scene with the most adequate digital effects for the 3Dmapping, with an effect list (or 'fx-list') as an outcome.
The contents have been produced especially in Maxon Cinema4D – for the operations of rendering and 3D animation – and Adobe After Effects – for 2D and 3D motion graphics, for the audio and video editing of the outcomes of Cinema4D and for exporting and finalizing the final contents (Figs. 6-11).
The contents production underwent three different phases. At the beginning a mask has been created: it is a rendered image which in 3DMapping becomes a bind – for matching digital frames and mapped surfaces – to build and scale the effects. Starting from this fixed canvas, taken as a default value, the second phase consisted in the production of the very contents, by translating into visuals what was determined in the storyboard. The software for each effect have been chosen according to the different scenic requirements, and the final scenes – both in 3D animation and in motion graphics – have been gathered and edited in a single continuous video sequence, according to the music composed ad hoc by the American composer and musician Joe Frawley. The third and last phase consisted in finalizing and exporting the video, later compressed in .H264 and prepared to the broadcasting before the final test.

6. THE AUGMENTED REALITY MOBILE APP

If compared to the productive process of the mapping, the workflow for developing the App has been more linear and, especially, way shorter. The possibility of dealing almost from the beginning with the production, and the different kind of treatment adopted for

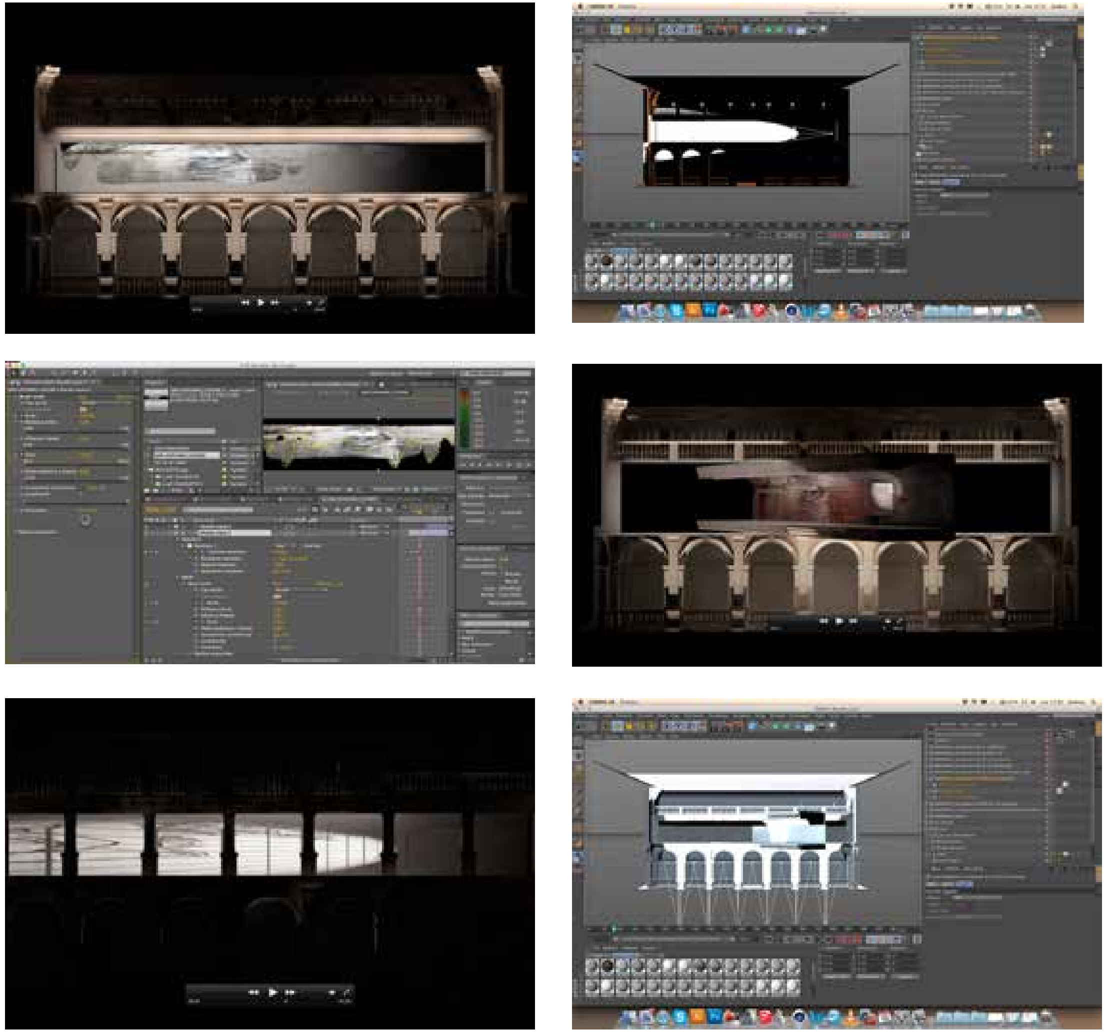
Fig. 5. A step of the reverse engineering of the cloister façade.

the contents, made it possible to focus more on the logical organization of data within the App than on their artistic and visual digitalization: this played a major role towards a simpler process, even if more difficult on a strictly technical level. The App has been considered as sort of virtual tour, with a first level of interaction based on the user's requests and another, automatic, based on the mobile device's position along the corridor. Most of the work lies then in the design and implementation of the inner architecture of the App which, for this reason, had to face logical and technical problems: these are especially concentrated in the managing of the interface, in choosing the system of activation of AR contents and in handling the core of the software development. As for the interface, a synthetic but accurate graphic and communication research has been conducted; starting from the analysis of the main analogous App in the same field, it has not been difficult to find a solution matching user-friendliness and stylistic quality (Figs. 12-14). The activation of AR contents, instead, has been the most difficult part, mostly because of the fragility of the context [12]: it was not possible to put markers on the paintings, obviously, nor it was recommendable to adopt ineffective solutions, so a more sophisticated method was chosen, based on a Bluetooth short distance triangulation system, determining in real time the position of the device handled by the visitor to activate one by one the different contents in AR, and superimposing them to the real object even without the presence of markers. The third and last critical point, related to the App implementation, is about advanced programming and scripting knowledge. The development has been made in Unity4D, one of the principal software platforms for gaming, AR and VR experiences and Apps. The wide community of developers, the presence of libraries of pre-compiled tools and scripts provided by the company itself, a workspace analogous to that of traditional

3D architectural and design modelling software and its very good editor for scripting (in C++ and Python) are some of the reasons why this platform has been chosen, despite being more dispersive if compared to other software specifically designed for App development.

7. THE PROTOTYPE AND THE OUTCOMES

The available time and the technical difficulties for the App forced us to stop at the stage of a partially working demo, then uploaded to a tablet to simulate its functioning even in absence of a real system of localization. The Mapping instead has been taken to a further step, by converting the set up prepared for the phase of testing to a real performance exported in micromapping: a scaled – but fully working – set up has been prepared by optimizing the operations of calibration and deformation, and also by choosing technical solutions (from a pico-projector to a pc-stick, substituting the common computer where the direction takes place) easily transportable and re-mountable. These have been associated to a physical and disassemblable model, prototyped by a last generation 3D printer whose level of detail – necessary for the full adherence between projected contents and physical support – has been guaranteed by the print of a .stl file generated from the same model employed for the creation of the contents, and more accurate than a common PLA model (Fig. 15).
The outcome of this phase, which relies on the whole (much wider) research project, is thus an innovative educational and divulgation protocol, that can be used to test on the market the efficiency of what is proposed without having to set up the full performance in situ. The advantages are many: obviously the project turns into something tangible and real, but this approach allows also to present the results of the research by exploiting their expressive potential, besides offering a communicative solution both for presenting the finished product and for monitoring possible upgrades and updates. The choice to employ micromapping, instead of a mapping in full scale, highly reduced the costs by freeing the phases of reviewing and of testing – often requested or imposed by the customer – from



Figg. 6-11. Workflow sequence, comparison between the effects processing in the software environment and in the final output.

Figg. 12-14. Graphic interface of the App, with examples of displayed informations.

the need to build expensive and bulky preliminary set ups in real scale. This operation is not only technically and logistically complex, but is often discarded a priori for the very high additional costs. From the communication point of view, lastly, having reconnected the projected elements with a physical surface already during the presentation phase allowed to outdo one of the biggest limits of 3DMapping shows: despite being easily understandable after the event through recorded videos, they are usually impossible to describe as a preview exactly because they are bound to the site specific broadcasting and to the effective correspondence between projection and physical object. The work that has been done therefore introduced an interesting innovation, and in this sense it can be taken as a pilot scheme for a new fruition conception of the cultural heritage, in line with what the actual market and the national and international cultural tendencies seem to suggest as a future direction.

Fig 15. 3D printing and final cleaning of the chalk prototype.

Fig. 16. Views of the disassemblable chalk prototype.

NOTES

[1] Cfr.: Laugier, J. (2014). Lyon: 3 millions de visiteurs pour la Fête des Lumières. (December 15th 2016), Retrieved from: http://www.20minutes.fr/lyon/1498023-20141209-lyon-3-millions-visiteurs-fete-lumieres; Schieck, A.F. (2009). Towards an Integrated Architectural Media Space: The Urban Screen as a Socialising Platform. Urban Screens Reader, 5.

[2] Cfr.: Gion, A. (2016). Immersive heritage. Il bene culturale, tra strategie di valorizzazione e soluzioni fruitive hi-tech (2016). In: Bortot, A. (edited by), Rappresentare i confini. Percorsi di ricerca tra arte e scienza (pp. 118-129). Milan, Italy: Mimesis.

[3] About the concept of 'intangible heritage' see e.g.: Cameron, F., & Kenderdine, S. (edited by). (2007). Theorizing Digital Cultural Heritage. A Critical Discourse. Cambridge, U.S.A.: The MIT Press; Tramontata, A. (2007). Il patrimonio dell'umanità dell'Unesco. Un'analisi di semiotica della cultura. (Phd Thesis in Semiotics). University of Bologna, Italy.

[4] Bruley, Y., & Rauwelp, A. (edited by). (2002). La Trinità dei Monti ritrovata, Rome, Italy: De Luca Editori d'arte.

[5] The concept of 'Immersive Technology' includes the technological solutions that allow to generate audiovisual experience – 3DMapping, AR, VR, holograms, 360° shooting – immersing the user on a perceptually altered dimension.

[6] Cfr.: Murray, T. (2008). Digital Baroque. New Media Art and Cinematic Folds. Minneapolis, U.S.A.: University of Minnesota Press.

[7] Maniello, D. (2014). Realtà aumentata in spazi pubblici. Tecniche di base di video mapping, vol. 1. Naples, Italy: Le Penseur.

[8] The photogrammetry survey of the corridor with the San Francesco of Paola anamorphosis, painted by Emmanuel Maignan, has also been used in a sequence of the movie Salt and Fire (2016) by Werner Herzog.

[9] The work carried out by the Imago rerum team, and coordinated by prof. Agostino De Rosa at the University Iuav of Venice, is part of the PRIN 2010-2011 "Architectural Perspective: digital preservation, content access and analytics", coordinated on the national level by prof. Riccardo Migliari, Sapienza University of Rome.

[10] According to the PRIN objectives, it has been chosen to acquire a minimum resolution of 4 pixels / mml.

[11] Cfr.: Calandriello, A. (2015). Andrea Pozzo a Roma. Nuove ipotesi fruitive del Refettorio di Trinità dei Monti. In: Bartoli, M. T., & Lusoli, M. (edited by). Le teorie, le tecniche, i repertori figurativi nella prospettiva d'architettura tra il '400 e il '700. Dall'acquisizione alla lettura del dato (pp 127-134). Florence, Italy: Firenze University Press.

[12] In its most common applications, the AR works in fact with a marker that allows, once pointed at with a mobile device, to upload a virtual content remotely and to superimpose it (within the display of the device) in real time to the object or to the work to 'augment'. This solution, the most widespread in AR, would have required a direct installation upon the surface of the mural painting, with consequences obviously conflicting with conservation.

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