“Musealising” the Virtual: the Virtual Reality Project of the Scrovegni Chapel of Padua

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Abstract

The Scrovegni Chapel, painted from Giotto in the period 1303-1305, is one of the most important masterpiece of the European art. Because of serious problems of preservation, the paintings have been restored in the last two years but the accessibility to the monument is now limited for number of visitors (20 people any time) and length (15 minutes at a time). In order to solve these problems of fruition the municipality of Padua has planned the creation of an hypermedia room (10 x 20 m) hosting multimedia and museum installations concerning the contextualization of the Giotto’s world and of the Scrovegni Chapel. The most important installation is a virtual reality system created by the Institute of Technologies Applied to the Cultural Heritage of the National Research Council (Rome, team directed by Maurizio Forte) aimed to a spatial 3D reconstruction and re-composition of all the information regarding the Giotto’s paintings and the internal architecture of the monument (33.000 polygons in real time, 500 links, more than 100 menus).

In this way the visitors of the Chapel (last year about 600.000) will can prepare virtually the real visit to the monument (1st alphabetization) and then, they will can come back to the virtual installation in order to integrate all the information they will need (2nd re-alphabetization). We have defined this process of digital cultural learning through virtual exhibitions “musealising” the Virtual”: the use of VR tools and applications will increase a reticular cultural learning (despite the traditional “linear” learning), catalyzing new consumes of virtual heritage.

1. The Scrovegni’s Chapel and the restorations

The decoration of the Scrovegni Chapel in Padua has been universally recognized as the most significant and most paradigmatic creation of Giotto and one of the capital events in the history of the European painting. The Chapel, dedicated to St. Mary of the Charity, was painted from Giotto in the period 1303-1305 on order of Enrico Scrovegni. The sequence of paintings covers all the walls with the stories of the Virgin and Jesus Christ, and, on the back wall, the artist painted a single grandiose scene, the Final Judgement.

Enrico Scrovegni, the Paduan sponsor of Giotto was a very highly placed personage. Very rich and ambitious, he acquired in 1300 the area of Arena in order to build a palace with a chapel. It was probably conceived as an offer to the Lord in expiation for the sins of usury committed by Enrico’s father, whom Dante placed in his "Inferno". In the 1880 the Chapel was acquired by the Municipality of Padua and, in the last two centuries different restorations were made.

Giotto’s sequence of paintings is develop on three themes: episodes from the life of Joachim and Anne, from the life of Mary, and from the life and death of Christ; in addition, the frescoes on the bottom tier of the Chapel represent the Virtues and Vices, while the Last Judgement is depicted on the inside wall of the façade.

Inaugurated on 18th March 2002 with the visit of Italian President Carlo Azeglio Ciampi, the Scrovegni Chapel, restored to its full beauty, is now open for visiting by only 25

visitors at a time. After twenty years of experimentation and study, the Chapel has been cleaned, not only removing the damp condensation stains caused by the transpiration of the hundreds of thousands of visitors who have flocked there in the past, but above all halting the dangerous sulphating process which causes crumbling of the plaster.

On the basis of this so difficult and short fruition and accessibility of the Chapel, a very complex and multimedia virtual project was born in 2001 by initiative of the Municipality of Padua. Within the general multimedia project a virtual reality systems for the Scrovegni Chapel has been directed by CNR-ITABC (National Research Council, Institute of Technologies Applied to the Cultural Heritage) in collaboration with the Municipality.

Fig.1 The virtual model of the Scrovegni Chapel

2. "Musealising the Virtual": the multimedia project for the Scrovegni Chapel

The general plan of the Municipality of Padua has involved the creation of an hypermedia exhibition room of 10 x 20 m, fit to host seven installations (physical and virtual exhibitions). The seven installations are aimed to learn the historic and artistic context in which Giotto lived and worked. This "cognitive box" can suggest the people passive and active interactions (interactive DVD, multimedia, movies, virtual reality) or physical reconstruction (Giotto's subjects and scenes like the St. Anne's house). This multi-interactive approach is aimed to introduce, to alphabetize and to contextualize the visit to the Chapel on the basis of a multifactor learning with three main steps: immersion, expectation, visit.

At the end of the real and of the virtual visit, the user will can come to explore again the virtual model, according to a process of informative *anakyclosis* (a "cognitive circle": virtual-real-virtual-real again). So the cultural learning, in the alternative real and virtual phases, comes for redundancy and for the spatial contextualization of the data; the user-

visitor follows informative paths adding in progress new levels of learning. The *anakyclosis* is concluded when a mental information is identified ("already seen", "already acquired", "already memorised") and with the faculty of elaborating it. In conclusion, starting from the redundancy of the informative geometry, dealing the same argument, a permanent cognitive *feedback* will can be created, increasing the faculties of learning and of memorising.

The installation typologies of the hypermedia room are distinguished by the following features: narrative (installation 1), virtual-cognitive (installation 2), multimedia (installations 3, 5 and 6), exhibited (installations 4 and 7). The installation 1 is a DVD displayed on a panoramic screen and it concerns a collective experience. The installations 3 and 5 are multimedia and interactive DVD movies; they produce context and feedback of the project; the installations 4 and 7 recreate a physical environment. The installation 2 (figs.1-6), the virtual reality system, is the focus of the exhibition and it represents the maximum level of interactivity and of virtual-cognitive increment.

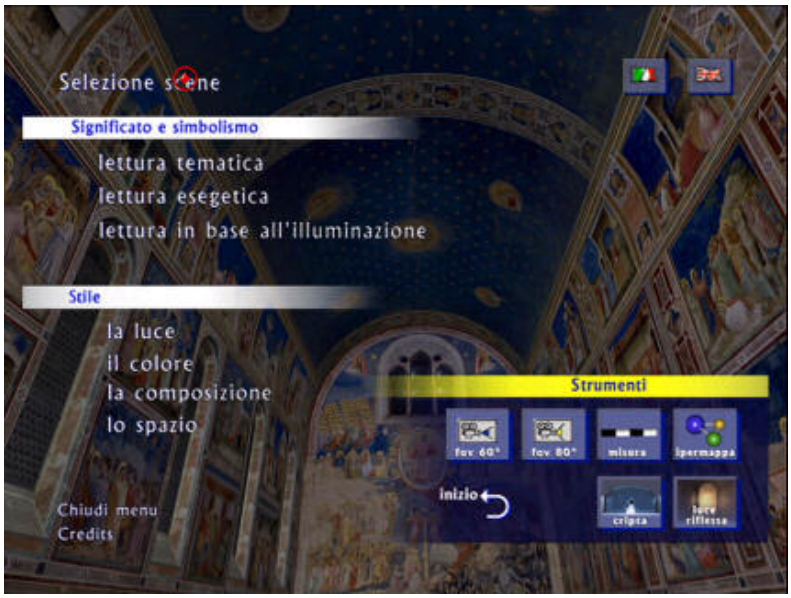

Fig.2. The main interface of the system with visual (on the right) and thematic tools (on the left)

Finally, one of the key points of the project is in the propaedeutic digital immersion to the visit (fig.1) and to the attempt of "musealising" the virtual, that is using the multimedia installations like a real museum exhibition, composed by its own grammars and expressive languages. So each installation has its own shared territory, represented by the space in which the visitors interact, and a contextual connective territory (virtual), where multimedia information are located according to an incremented reality. We can define this space an "invisible space" where each territory of attraction is located; on the basis of this territory the visitor can stop for a short or a long time, interacting with the digital content, exchanging collective experiences, finally recreating his own mental map with the visual and sensorial stimulation he receives and elaborates. In this direction the projects aims to "musealize" the Virtual, to re-create mutual interactions between all the installations.

2. The Virtual Project

On the basis of the above-mentioned considerations the accessibility to the Chapel is limited or in the time of visit, or in the strong difficulty to see and to understand all the scenes and the paintings (distance, light, complexity of the subjects).

Therefore the virtual reality project is aimed not to substitute the real visit to the Scrovegni Chapel (about 15 minutes), but to prepare it, to integrate it, to re-contextualize it, alphabetizing in real time the visitors with new and immersive visual grammars and with all the interactions in 3D and in real time (fig.1).

The sequence should be circular: before of the visit (virtual alphabetization) – during the visit (real alphabetization) – after the visit (virtual re- alphabetization); the great challenge of the project is to increase and to accelerate the cognitive impact of the cultural learning

through very advanced tools such as three-dimensional interaction in real time and hundreds of virtual behaviors of the application. Therefore, in a very short time, the users should learn and acquire much more information using VR than using "linear" tools and actions, such as books, audio guides, catalogues and so on. This interaction and learning in VR is of reticular type [1] (information spatially connected within a 3D cyber-net) because the use is immersed within reticules of information and visual data [2].

For example in the nineties most part of the virtual reality projects in the cultural heritage were involving 10-20 behaviors (interactions) for each application, while in our application we have 500 links and behaviors. We define a behavior a real-time interaction in the 3D space (3D hot areas, 3D movements and visualizations, 3D simulations, etc.). Each interaction is carried out from its own system of virtual alphabetization; a new "alphabet" can suggest a different and fast perception of the visual and interactive space; in this way advanced directions of digital learning will be promoted so that the audience can receive in a very short time a relevant quantity of information [3]. This mental re-composition is a new map (fig.6).

Fig.3 The Chapel seen from the crypt (the floor is transparent)

The application has been made by a multidisciplinary team of archaeologists, programmers, cognitivists, historians of art, multimedia experts, visual psychologists and this is one of the key points to stress: when we have a good synergy of social, human and hard sciences we obtain important results.

Finally this project suggests an important further consideration: what future will be for the fruition of cultural heritage with high risks of preservation ? Which aims the institutions for the protection of the monuments have to follow ? To protect the cultural heritage means also to detract to the public fruition ? In order to transform an "armored" (protected but not valorized) cultural heritage in a "disseminated" heritage, we think that the role of desktop virtual reality systems is fundamental, because it opens new horizons to the collective and domestic cultural fruition/consume.

4. Interface and technical descriptions

The characteristics of the interface are substantially different from canonical multimedia applications, because all links are integrated in the spatial model; for this reason all functions related to the movement and dynamic interaction must be supported. In the use of texture mapping we have provided for two levels of detail: a first intermediate level of detail for a comprehensive vision of the model and the scenes, and a second high level of detail where it is possible to appreciate every particular of each scene from a very near distance, simulating, in this way, a quality of visualization that is totally inaccessible during the real visit.

For navigating through the model, the user can use the mouse (free rotation) and some keys of the keyboard (linear movements in all the directions). The keyboard can be replaced by a console made on purpose, with only the necessary keys, constructed with more esthetical and functional attention to make it easier to use. In a second moment it will be possible to implement the navigation by the use of a joystick.

The application presents two versions: in Italian and in English language. The choice of the language is possible on the start of the program, and later, in every moment during the virtual exploration, by selecting the contextual menu. The starting interface of the application is the entrance into the chapel, where the user is free to navigate through the global 3D space. This spatial dimension represents the first level of detail. At the beginning of the navigation no themes are activated and no elements can be selected. For querying the scenes and for opening other types of contents it is necessary to visualize the main menu.

The main menu is accessible using the mouse right click to avoid visual disturbs during the virtual navigation; it is composed by two sections. The first section can be defined VISIT (available for both levels of detail) and it is relative to the sequences of the virtual visit according to the available documentation and to the level of detail of visualization; the second section can be defined TOOLS and provides some typological interactions and utilities in order to interpret the space of the virtual chapel and the organization of the structured contents. Some of these tools have been just implemented, other ones will be added in a future development of the project.

The main menu (fig.2), at the first level of detail, allows a free access to all the general types of readings and interpretations of the pictorial cycle and it presents the "magnifying scene" function. So, the items of the first section of menu (VISIT) are:

Magnify scenes

Themes concerning the general meaning and the symbolic content of the paintings:

Thematic reading

Exegetical reading

Reading according to the lighting of the walls

Themes concerning the pictorial style:

The light

The color

The composition

The space

The thematic reading is referred to the development of the story in the fresco scenes, and it explains the organisation of the narrative contents in three registers over the space of the walls (fig.4).

The Exegetical reading concerns the correspondence of symbolic content between couples of scenes of New and Ancient Testament, according to a custom of Mediaeval Art.

The reading according to the lighting of the walls proposes an interpretation of narrative and symbolic contents of the scenes on the basis of their conditions of lighting. For instance it is possible to notice that Giotto painted the stories happened by night, or characterised by a "psychological night", on the darkest wall of the chapel. Then the themes regarding the pictorial style are referred to particular innovative aspects of the Giotto's art.

Every theme is introduced by an audio comment, whose function is to anticipate some general concepts related with the theme selected; at the end of this introduction the most representative scenes or elements are pointed out in the 3D model and the user can select them clicking directly in the 3D space, in order to have access to particular contents. The second section of the contextual menu at the first level of detail, offers a kit of TOOLS, that allows the user to interpret the virtual and cognitive space in a more effective way.

FOV commands

There are two cameras available to explore and move through the 3D model of the chapel: the first one has a field of view of 60 degrees, the second one allows a wider visualization of the space with a field of view of 80 degrees.

Measure command

It is possible to visualize into the 3D model a tool of measure, partitioned in meters, showing the dimensions of the chapel: height, width, length. In addition a human silhouette allows to establish the spatial scale and to acquire a correct sense of proportions.

Cybermap command (fig.6)

Thanks to a three-dimensional cybermap (an hypertextual map in three dimensions) it is possible to compare the informative "planets" proposed by the applications and all the connective networks of information, exploring their spatial relations. In the cybermap a scene becomes a cube, a theme a solid, different colors distinguish classes of information and semantic associations. The cybermap can be defined as a compass, helping to understand the informative skeleton of a cultural product (a sort of digital "genetic code"). Since the space in which it extends corresponds with the virtual space of the chapel, it is always possible to examine to which scene or group of scenes of the pictorial sequence the conceptual links are associated.

Fig.4. Colored outlines over the paintings show different hot areas and hyperlinks

Crypt command (fig.3)

In the Crypt under the chapel, inaccessible to visitors, another vault full of stars has been discovered; the application allows to enter into the crypt and looking, in transparency, through the sky of this vault, at the entire decoration of the overhanging chapel. Perhaps this is one of the mysteries of Giotto's art: to represent the chapel (or two chapels ?) through two world: Worldly, the crypt, and Heavenly, the chapel with the Last Judgment.

Reflected light command

This command allows to simulate hypothetically the light of torches on the painted walls, because it is not clear yet how the chapel was enlightened in origin. The effect emphasizes shining and thickness of gold haloes.

Illusion command

In a future upgrade of the application the reconstruction of all the scenes in three dimensions will be implemented in order to allow the users to enter into the frescos with new perspectives of spatial display.

Fig.5. Interface of a scene in the second level of detail: themes and characters

Restoration command

In a second step of the work it will be necessary to visualize the textured model with the orto-photomosaic of the last restorations. This documentation is very important because it adds further tools of interpretation of the structure and of the style of the paintings.

4.1 The second level of detail

When we choose a scene to

magnify, we activate the second level of detail (figs.4-5), so it is possible to explore each single scene at a higher resolution. Approximately each scene occupies 35 MB of graphic memory. The contextual menu at this second level of detail contains the following items:

Themes concerning the understanding of the specific meaning of the scene:

Description

Characters

Other themes related with the pictorial style, available for the selected scene:

The Light

The color

The composition

The space

If *Description* is selected, an audio comment will explain the narrative content of the scene. If a *character* is selected a short text will appear and it will identify the character, explaining the action he his performing and quoting the Bible section that describes him in the represented attitude.

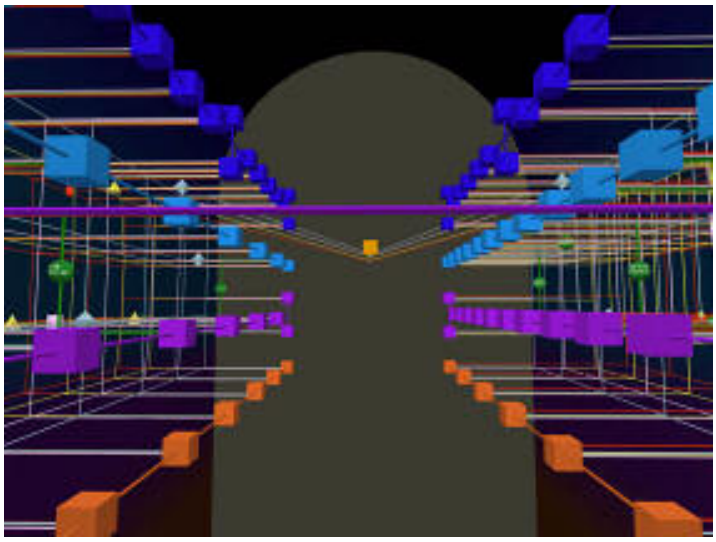

Fig.6. 3D Cybermap

In this way it will be possible, in each scene, to reach a lot of themes transversally. For instance, if a user is examining *the composition*, he can proceed to *the space,* selecting it from the second level menu, without being obliged to come back to the first level menu.

4.2 The Last Judgement

The emotional and solemn impact of the Last Judgment has requested a different organization of information and some dedicated interpretations. The contextual menu contains some specific items for examining and understanding complex spatial structure and symbolic meaning of the representation. For instance it is possible to listen to particular comments about the representation of the space, on the basis of the hierarchical relations and of the geography of the hereafter, such as they were imagined in the Middle age.

4.3 Music and sounds

Music is introduced in a random way into the virtual exploration; contemporary pieces alternate with other types of sounds and effects: ancient choral pieces, electronic music, voices, murmurs, whispers, stampings on the floor, dripping water and so on. This musical dialectics produces a more effective and disquieting emotional impact in the user.

5. C++ Programming

It is important to stress that this project was directed from the beginning towards desktop applications for PCs and personal workstation equipped with OpenGl graphic cards; in particular we have implemented the system for graphic cards Wildcat III 6110 with 128 MB texture, 64 MB frame buffer, 16 MB direct burst and antialising. With this configuration we have obtained a frame rate of 40; in terms of general statistics related

with the software and the virtual model we have: 82.561 code lines, 33.603 polygons, 3 GB of textures, 1.2 GB of audio, 100 menus, 500 links.

Main aim is to create an application easy to use and very stable because we estimate an intensive use from hundreds people for ten hours each day. The application was written in C++ without using graphical commercial library or engine [4]; the operating system is Windows 2000 Professional.

For the best comprehension of the structure we can subdivide it in these items: rendering, texturing, geometry data, sounds, text, user interaction. A Finite-state machine with all the possible conditions was created in order to manage all the situations of free navigation.

Rendering: the choice of OpenGL was necessary because the Wildcat graphic cards don't have a full support of DirectX. This limitation imposes us to not use DirectShow in some situations like full screen movies. Very often we use two layers of visualization: the back layer with the free 3D navigation and the front layer with bi-dimensional images synchronized with an audio file. This was possible creating one viewport with the back layer with a perspective projection and the front layer with an orthographic projection, rendered in the same time. This mechanism was used also for the 100 menus of the application and for display the text.

Textures: a serious problem we have faced up was the high resolution of textures. It was clear that the most powerful graphic card don't have video memory enough to display all the textured chapel with an adequate resolution. The solution was to create two main states: the first level, with all the chapel mapped with 72 textures, with a dimension of 512 X 512 pixel each one, and the second level, that presents a single scene composed by 9 textures of 1024 X 1024 pixel each one. A strong attention was paid to avoid possible memory leaks during the swapping.

Geometry: the application loads in memory the geometry data during the *init* function. A DLL was created with all the data disposed like OpenGL Display List. The total amount of the data is 2.50 MB.

Sound: we have used DirectSound with some simple functions.

Text: In some situations the user can activate a small text scrolling in the screen. The text is a front bi-dimensional layer over a 3D back layer.

User interaction: we can divide the user input in two main groups: the navigation input and the query input. The navigation input is in 3D space, the user can use the mouse to rotate the camera and 6 keys to move the camera in any linear direction. In order to query the scene the user have two possibility: to pick one hotspot in the 3D space or activate, with a right click, a contextual menu. In some situations the user can pick till 87 hotspots in the model, while the maximum number of items in the menu is 20.

6. Conclusion: epistemology of the Virtual

A very complex virtual reality project such as the case of the Scrovegni Chapel, suggests several considerations or technological or epistemological. The first depend strongly on the second and represent a fundamental base of discussion for interdisciplinary projects and for a correct interpretation of the cybernetics and of all the applications in this field.

According to Howard Rheingold [5] we can imagine virtual reality like a magic window open to other worlds, from the molecules to the mind. About Wooley [6] the virtual reality is that technology used for creating a specific interface between human being and images produced by computer.

About Pierre Levy virtuality and actuality are two different ways of being: the Virtual is not the opposite of the Real but of the Actual [7].

So, the Real is diluted in the Virtual, it represents its conceptual thought, visual and abstract, anyway communicative. It is fundamental to avoid in toto the opposition of Real-Virtual (both are ontology), but also to understand the Virtual as "succedaneum" or a

simple simulation of the Real, because this simplification doesn't help to understand the epistemic value of a complex technology. The artificial world can't simulate the Real, but it can increased it, decreased it, code it, interpret it.

It is a common opinion to think that the search of the photorealism is a primary goal of the virtual reality, but the Virtual doesn't aim to the Real, but it changes about its representation. The digital photoreality doesn't increase necessarily the perception, it fits simply description and illusion of the reality to the artificial worlds. In the digital photoreality the illusion to model the Real is created, but anyway a new context is created, that is a new Real. Therefore contextualization and spatial connectivity of the information represent the base of this type of digital technology. On the basis of this principle of cognitive visualization, the more the interactivity seems very close to the Real, the more the orientation and alphabetization of the user will increase.

On the opposite virtual reality has to suggest new grammars of communication and inter-connection, directed to the exchange of information, events and behaviors, apart from principles of likelihood to the "true" or to the "presumable". For instance, walking through the ancient Pompeii reconstructed in 3D like "it was", I don't have necessarily a significant exchange of information between my mental map and the topography of the site, but I should have it in the creation of new mental maps and visual grammars, in the contextualization and spatial measurability of the data. [8].

The rules of meta-representation of the Virtual regard also the artistic thought: with regard to this, Arnheim writes that: "If we consider famous pictures of the past– Raphael's, Rembrandt's […] – without a deep attention – they would have seen expressly precise copies of natures, landscapes, insides, still life, human beings. Was it probable that they knew presence of totally abstract patterns and, as images, they meant something of completely different ?" [9].

The same principle ruling construction and perception of abstract patterns, of sensible informative geometry, much different from the Real, can be found in the virtual reality applications and they represent a visual thinking. Virtual Reality is itself symbolic, because it communicates through abstractions: "An image acts like a symbol when it figures things at a higher level of abstraction than the symbol itself is [10].

According to the cybernetics of G.Bateson, the learning is "through difference", the perception acts only on the difference. Receiving, grabbing information means always and necessarily to receive news of difference, and perception of the difference is always limited from a threshold. Differences too slight or presented too slowly are not perceptible: they don't feed the perception. Science doesn't prove, it tries. The Bateson's theory of the knowledge is fit to explain the mechanisms of processing information: data are neutral objects, the knowledge of a spatial system is for interaction (difference) between the components or for the simulation of connected events. The more difference increases in the virtual interaction, the more learning increases.

According to the thought of Korzybski "the map is not the land" [11], in the virtual reality the "map is the land": this is the "cybernetic revolution", or the priority scientific aim of the virtual reality. In the Virtual the "difference" represents the cognitive value of the artificial environment, of the logic of the reticular learning; in the dynamic of events and interactive environments, a difference is created, preamble of the cognitive acquisition.

The Virtual can be interpreted in structuralist sense, where the whole, interpreted like context, is more than any single part, because it increases the level of information [12]; the construction of the context is the first step for enriching, increasing the learning. The construction of the context is the fundamental base for increasing the learning, opening new perspectives and cognitive approaches. In this increment the epistemic value of the technology was identified: to catalyze the psico-perception and the learning through visual and informative complex environments.

In the field of the cultural-virtual heritage the predominance of the "visual" than the "perceptive" dominated most part of the projects of the nineties. It is important to remark that, actually, the potentialities technologically and cognitively more interesting are: interactivity, events, behaviors, multiusers, immersivity. A new and disseminated revolution of the virtual reality has to be started or it is starting.

This is the Batesonian methodological approach we have followed in this project; it demonstrates how it is possible to write C++ software for cultural heritage applications and, specifically, for PCs with OpenGl graphic cards applying a specific and coherent philosophy of visual thinking and reticular learning. In terms of technology and methodological approach we believe that DVR systems open new meaningful perspectives for fruition, valorization and learning of cultural heritage: low cost hardware and new devices of visualization will increase a strong and new consume of virtual-digital heritage. In the case of the Scrovegni Chapel we hope it is possible to create satellite virtual reality centers out of the territory of Padua, so that to increase the virtual visitors of this masterpiece of the western art: that is, new consumes of digital cultural contents produce a wide dissemination of the world cultural heritage, saving our collective human memory archives.

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