Abstract

The Last Supper Interactive application is an immersive and virtual interactive experience meta-aesthetic experience in Leonardo's Last Supper painting (fresco). The user can explore in first hand and in immersive ways the power of visual perception and illusionistic effects of depth via the perspective of Leonardo's Last Supper, penetrate, step in and out and explore in real time from any perspective the three dimensional composition of Leonardo's painting. LSI also allows the view of the Center of Projection (vanishing point) located in the right side of Christ's head, on four modes: from the front side (aligned with the real space of the refectory); from the front side of the painting (aligned straight, to the vanishing point); from the back side of the painting, (aligned with Christ's viewpoint) and from any perspective, 360 degree. An immersive interactive learning tool (Alberti’s theorem virtual tool) was designed ad hoc for LSI to explore and demonstrate the linear perspective use in Leonardo's Last Supper painting.

This paper presents diverse aspects of the project, including concept, vision, project phases, goals and objectives achievement, history and background, hardware and software, interactive platform and visualization displays system, technological challenges and accomplishment, upgrading, state of the arts, project description and salient features, user experience and interaction, next step and phase development.

Key Words

Art, architecture, mathematics, Leon Battista Alberti, Leonardo Da Vinci, the Last Supper, immersive virtual (stereoscopic) environments, real-time learning scenarios, virtual tool, high definition imaging and visualization, linear perspective, perception, illusionistic effects of depth via perspective, motion golden radio, intuitive and haptic navigation and interaction, virtual storytelling, interactive narrative, cultural heritage.

1. Introduction

1.1. Motivations

Artists in the early part of the Renaissance struggled to master techniques to create an accurate illusion of three-dimensional space in their paintings (1) Artists searched for ways to make two-dimensional paintings accurately represent the three-dimensional world they saw around them (2)

In 1435, Leon Battista Alberti (1404-1472), has provided the first theory of what we now call linear perspective on Painting in his book. The impact of this new system of measurement in paintings was enormous and most artists painting in Europe after 1435 were aware of the principles Alberti outlined in his book. (3) Leon Battista Alberti’s Della pittura is the first modern treatise on the theory of painting. Although it appeared at a moment -1435-36- when the old and the new order in art were still existing side by side in Florence, it broke with the Middle Ages and pointed the way to the modern era. (4) Alberti’s own Italian translation from his Latin original probably entered the shops as something of an 'inspirational handbook' and became so popular that it was read out of existence. By the sixteenth century the Italian version was unknown. [5) Once Leon Battista Alberti published a mathematical method for calculating linear perspective accurately; other artists learned the method and became better at linear perspective. (6) As a result the art of painting was given a new direction which made a return to the Middle-Ages all but impossible. (7)
The Last Supper Interactive can be considered an engaging immersive interactive application and virtual tool to explore and demonstrate how a traditional technology and master technique such as the linear perspective, a mathematical system for creating illusion of space and distance on a flat surface. was applied by Leonardo Da Vinci to achieve an accurate illusion of three-dimensional space in two-dimensional paintings such as Last Supper, one of the finest examples we have of architectural forms created in perspective.

2. Project Phases

The LSI application was conceived as a seven distinct phase project to be carried out over planned years. Until date 5 phases have been accomplished.

Each phase outcome/results of the LSI application was conceived to run as a standalone application. LSI application has been exhibited through diverse immersive visualization systems at a large number of venues from the completion of the first phase onwards; a good number of publications (papers, articles, essays, book chapter) have been published to date.

The project plan next step is to pass to Phase 6.

3. Project Goals and Objectives (LSI Phase 1 to 5)

- To implement an immersive stereoscopic interactive meta aesthetic experience in Leonardo’s Last Supper fresco painting, allowing users to penetrate, step in and out and explore in real time from any perspective the three dimensional composition of the painting.

- To explore first-hand and in immersive ways the power of visual perception and illusionistic effects of depth via the perspective of Leonardo’s Last Supper painting.

- Facilitating advanced virtual access and stimulating learning experiences with Renaissance cultural heritage assets such Leonardo Last Supper, before, during and after a real visit which can offer further user comprehension, knowledge discovery and exploration.

- To design and implement an immersive interactive learning tool ad hoc for the LSI with for the following functions:
  
  - To Explore and understand through an immersive interactive learning tool the use of geometrical method of the linear perspective in a two-dimensional works of art such as the Last Supper which uses the one point linear perspective.
  
  - To experience in real time the construction of one linear perspective, used in Leonardo’s Masterpiece.

  - To demonstrate on immersive ways how Leonardo applied the "costruzione legittima" to draw the lines of perspective.

- To use advanced technology, innovative visualization and interaction techniques for enhancing user-driven virtual storytelling and interactive learning environments for the active fruition of artistic content and cultural heritage experience.
To explore the opportunities offered by minded innovation and leading edge technologies to empower the implementation of immersive design solutions comprehension-fostering based tool which incorporate more engaging and creative learning methods; that improves the meaningful use of edu-entertainment experiences users get from cultural and historical resources stimulating curiosity, exploration, communication and fostering faster concepts comprehension.

- Bringing technological innovation to the museum structure and archaeological site in the pursuit of the enhancement and greater valorization, fruition, communication, dissemination and promotion of the cultural heritage through the use and implementation offered by advanced technology enhancing creativity, knowledge and sensibility toward the art, culture and the humanities.

4. History and Background

4.1. History

The official launch of LSI took place in The National Museum of Science and Technology 'Leonardo da Vinci' in Milan, Italy. The first version of the LSI virtual reality application was integral part and hosted within a larger Virtual Reality application by the same author, Franz Fischnaller entitled: The Multi Mega Book in the CAVE® [MMB]... “The shift from the printed book to the electronic text & digital skin”: a virtual simulation of a 3x4 meter full immersive, real-time rendered an interactive book, where visitors can enter into, walk around, fly, interact, explore and navigate within alternate virtual immersive environments and narrative storytelling related to the Renaissance and to the Electronic Age.

MMB is an artistic virtual-reality journey through some of the most revolutionary moments of the human experience in media, technology, science, architecture, and art from the Renaissance through the Electronic Age. The user creatively interacts with and experiences the shift between two revolutionary moments in the history of communication, and consequently, the history of humankind: 15th century printed communication and 21st century electronic communication; designed primarily to run in the CAVE® Virtual Reality Theatre; the MMB allows the interactive visitor free exploration of various dimensions of both centuries.

The first interactive public presentation of LSI virtual reality application took place at the Ars Electronica Center, Museum of the Future, Linz/Austria and is part of the permanent exhibit in the CAVE Ars Electronica Center. The MMB application and all relevant content was winner of the Foreign Title Award in the Theater and Exhibition Section Multimedia Grand Prix, Japan.

4.2. Technological Challenges and Achievement

Several characteristics of this application have presented diverse technical challenges and have revealed innovative aspects in relation to networking interactive narrative techniques, architecture, digital effects, and content management. The structure of the LSI and the MMB has been furnished with a special series of additional software features to satisfy content and to enhance high-quality levels of interactivity.

The development and implementation of the LSI MMB has required the use of “XPn", an authoring system for immersive art exhibitions, developed by Dave Pape (PhD, EVL, The University of Illinois at Chicago). At present, the XPn is known as the Ygdrasil system and provides a framework for creating large-scale, interactive virtual-reality applications.

The XP system grew from software developed for the Multi Mega Book in the CAVE. The application was further refined during the development of “Mythologies." Both applications are large-scale environments. Most of the artists involved were experienced with tools such as Softimage, Photoshop, and basic Unix, but
were not professional computer graphics programmers. The goal was to create a framework which included many of the features common to virtual art environments, one that would allow experienced VR programmers to build tools needed for the features unique to a specific application, and allow artists to create the final environment by assembling the appropriate pieces.

The XP system provides a framework for creating large scale, interactive virtual-reality applications. By dividing the development of applications into two distinct components - the coding of nodes that encapsulate specific behaviors and the assembling of these nodes into a scene - XP allows teams comprising both artists and programmers to work on projects efficiently. It has been used to develop several successful artistic virtual worlds. Although originally developed for art applications, the general system should be useful in building a wide range of virtual worlds. [3]

XP is based on Performer, the CAVE (TM) libraries, a sound library and C++. The system is divided into two major aspects: the text file(s) defining an application as a collection of nodes and their connections via events and messages, and the lower-level C++ classes which implement the nodes. With this division, it is possible to split the work of world-creation between experienced programmers and non-programmers. The programmers create any new node classes which are needed for application-specific behaviors, such as graphical effects or elements of a character’s intelligence. The other team members build the full application by plugging together object and behavior nodes in the text files. In practice, there is likely to be an overlap between these groups; because XP handles many of the trickier details of Performer and the CAVE™ libraries, artists have been able to start doing some of the C++ programming of new nodes using a prototype class template. The XP framework also makes it easier to re-use code between applications, because the code is in completely modular nodes with standardized interfaces. Application authors create a virtual environment in XP by editing a scene file.

One of the central scenes to the MMB is an extensive city; users are free to explore the city as they wish, but of course, it is important that they don't get lost or miss the important parts. To help them, key frame-animated characters are placed in the city to act as virtual tour-guides; when users approach a guide, it will lead them to a nearby point of interest.

The basic XP system is designed for single-user applications. However, further extension of the system to support networked, multi-user worlds has begun. Using the CAVE soft networking architecture, a scene graph is replicated among multiple CAVEs; changes made by one user are automatically shared with all others. This approach was used in building the V-Mail (virtual mail) system for collaborative design. New node classes were created which can record user actions and spoken comments, and then send them to remote collaborators, who may be in the shared environment at different times. Future plans include such networking of the scene graph at the core of the system. [5]

Virtual-reality applications can use a wide variety of methods for animating. The MMB makes use of flipbooks, key framing, motion capture, and procedural (computer-programmed) animation for various purposes throughout the application.

Designed primarily to run in the CAVE®, a multi-person, room-sized, virtual-reality system at the Electronic Visualization Laboratory of the University of Illinois at Chicago, the MMB is capable of running on a number of different VR platforms, including the Immersa-Desk and simpler graphics workstations.

The CAVE® is a room, measuring ten cubic feet, with screens for walls. High-resolution stereoscopic images are rear-projected onto the walls and the floor and viewed with lightweight LCD stereo glasses to mediate the stereoscopic imagery. Attached to the glasses is a location sensor. As the viewer moves within the confines of the CAVE®, the correct perspective and stereo projection of the environment are updated and the user may walk around or through virtual objects. The CAVE’s room-sized structure allows for multiple users to move around freely, both physically and virtually. The users interact with the environment using
“the wand,” a simple tracked-input device containing a joystick and 3 buttons. It is used to navigate the virtual world and to manipulate virtual objects within that world. [6]

New and recent phases of the LSI application are in development and are migrating to a new framework and it’s expected to run on open source software and Unity 3D.

The principal partners and contributors in this phase development were among others: the Electronic Visualization Lab (EVL), the University of Illinois at Chicago, USA, The Università degli studi of Milan, Italy, The National Museum of Science and Technology ‘Leonardo da Vinci’ in Milan and at the Ars Electronica Future Lab and Ars Electronic Center, AEC, Austria.

4.3. Hard- & Software

The first version on SGI and Linux platform was written with the custom made Software "XPn" Authoring System for Immersive Art Exhibitions, based on Performer and the CAVE™ libraries, a sound library, and C++. The system and the application was further developed and built in Ygdrasil software; Ygdrasil requires EVL’s CAVELib® and the CAVERNsoft® (after Quanta) networking library; CAVELib® which is still currently a commercial product distributed by VRCO and CAVERNsoft and now by Mechdyne. The implementation of Last Supper Interactive virtual reality application has given rise to a range of technological challenges, which in turn have revealed innovative aspects and salient features relative to content management, the development of juxtaposed virtual environments, networking interactive techniques, avatar design, architecture, and virtual effects. A series of special features and enhancements have been added to the software Ygdrasil, to satisfy content and quality levels of interactivity. In consequence, the Ygdrasil system was further refined as software tools that aid the rapid and intuitive development of interactive virtual environments for artists and other nontechnical users.

4.4. Interactive Platform and Visualization Displays system

The first version of LSI virtual reality application, a full immersive stereo application, accomplished in the Project second phase was primarily designed to run in the CAVE® (CAVE AUTOMATIC VIRTUAL ENVIRONMENT). CAVE is a multi-person, room-sized, full-immersive virtual-reality system and installation with high-resolution stereoscopic images running either local or through remote networking in SGI and Linux platform. The CAVE® a multi-person, room-sized VR system was first developed at the Electronic Visualization Laboratory (EVL) at the University of Illinois at Chicago.

In the third phase development LSI was also adapted to other interactive platform and visualization display system and thereof capable of running on a number of different VR platforms, including the Immersa-Desk C-wall and AGAVE™ display system (Access Grid Augmented Virtual Environment) and simpler graphics workstations.

4.5. Upgrading and version Interactive Platform and Visualization Displays system

A second version of LSI virtual reality application was adapted to a simple graphic workstation for the Venue Virtuality & Interactivity I (V&I) International exhibition of digital arts and applied research of MEDIARTECH [Digital Renaissance]; MEDIARTECH, international multimedia venue dedicated to cultural heritage, digital and performing arts, promoted by the City of Florence and the Region of Tuscany, Italy. The principal partners and contributors in this phase of development were among others: The City Hall of Florence, the Municipality of the Region of Tuscany, the Tuscany Hi Tech Network, Italy, the Electronic Visualization Lab (EVL), and the University of Illinois at Chicago, USA.
A third version of LSI virtual reality application was adapted to MAV (Virtual Archeological Museum of Herculanum, Italy) a large-scale display system for data visualization (9x3 meter), represented at the Venue: Expanding the Frontiers of Utopia ... From the Digital Renaissance... to Space on Earth Project.

The principal partners and contributors in this phase development were among others: The City hall of Naples, Province of Naples | Assessor for the Cultural Goods | Municipality of Herculanum | Region Campania CIVES Foundation | Agency Ville Vesuviane.

5. LSI VR Application salient Features, Interactivity, State of the Arts

5.1. Summary

LSI VR application is a full immersive real time virtual interactive (stereo) application for large-scale visualization platform and others VR display systems based in the Last Supper of Leonardo Da Vinci. This piece aims to offer a creative experience in the language of Art and interactive storytelling. Emphasis was given to the virtual representation of Leonardo's Last Supper immersing visitors inside the picture enabling a deeper sense of Virtuality and emotional involvement, providing an innovative user-driven personalized access to the art work, allowing the user to visit and interact in all its details the painting becoming an active fruit or, a participant user and (active) spectator within the Last Supper of Leonardo Da Vinci.

5.2. The Last Supper of Leonardo Da Vinci

The Last Supper (Italian: Il Cenacolo or L’Ultima Cena) is a 15th century mural painting (15×29 ft) it covers the end wall of the dining hall at the monastery of Santa Maria delle Grazie in Milan, Italy. It was created by Leonardo da Vinci. The painting was commissioned by Duke Ludovico Sforza and his duchess Beatrice d’Este Sforza to be the centerpiece of the Sforza family mausoleum. Leonardo began to work on The Last Supper in 1495 and completed it in 1498; he did not work on the painting continuously.

The Cathedral of Santa Maria delle Grazie (“Holy Mary of Grace”) is a church and Dominican convent in Milan, northern Italy, included in the UNESCO World Heritage sites list. The church contains the mural of the Last Supper by Leonardo da Vinci, which is located in the refectory of the convent. The architectonic construction and design of this 15thcentury Milanese cathedral are attributed, in part to the architect and sculptor Filippo Brunelleschi.

The Last Supper represents the scene of The Last Supper from the final days of Jesus (as it is told in the Gospel of John 13:21) and it specifically portrays the reaction given by each apostle when Jesus said one of them would betray him. All twelve apostles have different reactions to the news, with various degrees of anger and shock.

Leonardo’s masterpiece may be considered an outstanding example of the Renaissance synthesis between art and science; in fact, the mathematics of geometric construction was well established and known both to the scientist and artist of the epoch. Computer-based perspective representations are the result of a continually growing body of knowledge, allowing us now to compute accurately the numerical parameters of ancient methods of construction.
5.3. Users Interactive Experience in LSI VR Application

5.4.1. Summary

When the user approaches the Leonardo's Last Supper from the center the fresco wall fades into a transparent layer morphing into a 3D immersive environment. The user penetrates the surface of the wall and “steps into” being full immersed into the three dimensional composition of the painting.

Once inside, the user can explore the 3D space and feel the paintings composition in a 360 degree viewpoint, he can navigate close to the Apostles moving around the table, and explores the painting from the height of the horizon, from the front and back, look out from the viewpoint of Jesus Christ, observing from the back stage of the painted architecture into the 3D simulation of the real architecture of the refectory.

The user experiences in first-hand the relationship between the real architecture of the Refectory and the painted architecture by Leonardo.

Leonardo's masterpiece, The Last Supper becomes the threshold of perspective. In the real visit is limited to viewing the painting from a distance of six meters, and 4.6 meters below the horizon line; the MMB visitor may use the application to observe it from a very close viewpoint. Instead through the Last Supper Interactive the visitor can observe it from different viewpoints get very close, see each detail and immerse into the 3D virtual simulation of the painting.

5.4.2. Key features and highlights: LSI VR User Interaction

- To get fully immerse into an immersive stereoscopic interactive three dimensional composition based on Leonardo's Last Supper painting and to penetrate, step in/out and explore: front, back and within the three dimensional composition of Leonardo's painting in real time from any perspective.

- To explore in first hand and on immersive ways the power of visual perception and illusionistic effects of depth via the perspective of Leonardo's Last Supper painting.

- To look and navigate front, back and within the vanishing point located near the center of the horizon line in the right side of Jesus Christ head and to observe and navigate from the Jesus Christ's viewpoint observing from the backstage of the painted architecture into the real architecture of the refectory.

5.4.3. LSI VR Users experience in relation to the Center of Projection

In the real world the viewer /visitor can see the painting from 8-6 meter distance and 4.6 meters below the horizon line. The LSI application allows the interactive user to view of the Center of Projection (vanishing point) located in the right side of Christ's head, in four modes:

I. From the front side, aligned with the real space of the refectory, 4.6 meters bellow to the center of the projection;

The center of projection (which is at the height of the horizon) is 4.6 mts above today's floor. In the real world, when the viewers /visitors are physically in the refectory the correspondence between the center of projection and the spectator’s vantage point is of 4.6 mts. The center of projection is so high that only a
person about three times as tall as the average could see the picture from the center of projection; physically experienced space.

II. From the front side of the painting, aligned straight, to the vanishing point, above floor Level / 4.6 mts.; physically inaccessible for the physically viewer but possible through the LSI virtual simulation.

III. From the back side of the painting, aligned with Christ’s viewpoint, above floor Level / 4.6 mts; The user can explore the view from the Jesus Christ’s viewpoint, navigate from the backstage of the painted architecture and view from that perspective into the real architecture of the refectory.

IV. From any perspective, 360 degree

5.4.4. Alberti’s Theorem virtual tool (ATVT)

5.4.4.1. Summary

An immersive interactive learning tool (Alberti's theorem virtual tool) was designed ad hoc for LSI to explore and demonstrate firsthand the geometrical method: the linear perspective applied in Leonardo’s Last Supper and to explore the relationship between the real architecture of the Leonardo’s painted fresco on the side walls of the refectory (refettorio), among other function.

ATVT was inspired in Leon Battista Alberti rules of linear perspective (Costruzione Legittima and the “viewer” of Filippo Brunelleschi implement in the early 1400s demonstrating its principles.

Leonardo's masterpiece may be considered an outstanding example of the Renaissance synthesis between art and science; in fact, the mathematics of geometric construction was well established and known both to scientist and artist of the epoch. Computer-based perspectival representation is the result of a continually growing body of knowledge, allowing us now to compute accurately the numerical parameters of ancient methods of construction.

Metaphorically in the LSI application the Alberti’s theorem method becomes Alberti’s theorem virtual tool.

In the main theorem concept of Alberti’s Costruzione Legittima the diagonals of any square on a horizontal plane, centrally projected onto the projection plane, intersect the horizon at a point whose distance from the vanishing point equals the distance of the viewpoint from the projection plane. [Vanishing point: In linear perspective, the place on the horizon where parallel lines seem to meet.

5.4.4.2. Alberti’s Theorem, “costruzione legittima”

In 1435, Leon Battista Alberti (1404-1472), provided the first theory of what we now call linear perspective, the idea that converging lines meet at a single vanishing point and all shapes get smaller in all directions with increasing distance from the eye. The impact of this mathematical method in paintings was revolutionary and as a result the art of painting was given a new direction braking with the Middle Ages and pointed the way to the modern era.

In the main theorem concept of Alberti’s Costruzione Legittima the diagonals of any square on a horizontal plane, centrally projected onto the projection plane, intersect the horizon at a point whose distance from the vanishing point equals the distance of the viewpoint from the projection plane. [Vanishing point: In linear perspective, the place on the horizon where parallel lines seem to meet]
Linear perspective gives the illusion of 3-dimensional images on a 2-dimensional support. In the Renaissance, painters needed to be able to translate the three-dimensional world around them onto the two-dimensional surface of a painting, called the "picture plane." Leonardo used perspective to elevate the viewer to an extraordinarily high center of projection, thus achieving a feeling of spiritual elevation.

5.4.4.3. **Interacting with Alberti’s theorem virtual tool**

Users can interact in real time with Alberti’s theorem virtual tool within the full immersive 3D space of the Last Supper Painting and overlay the virtual tool demonstrating and experimenting with creative ways the perspective composition of Leonardo’s Masterpiece.

The positioning of the 3D virtual theorem onto Leonardo’s viewpoint in the painting demonstrates the exact position of horizon and vanishing points. The computer program constructs the homogeneous coordinate representation of the painted space, performs the linear transformation perspective space, and produces the final projection on the visualization plane in Cartesian coordinates in the three dimensional space imagined by Leonardo.

**Key Performances and Interactive Highlights of Alberti’s theorem virtual tool**

- Explore and understand the use of geometrical method of the linear perspective in a two-dimensional works of art such as the Last Supper which used one point linear perspective.

- Experience in real time the construction of one linear perspective, applied in Leonardo’s Masterpiece in real time.

- Demonstrate on immersive ways how Leonardo applied the *costruzione legittima* to draw the lines of perspective.

5.4.4.5. **Interactive Scenes / Virtual Scenarios**

5.4.5.1. **Description**

LSI application is a nonlinear sequence design solution, a real time immersive virtual application for the fruition of the content upon visitors’ navigation and interaction. On a broader sense of the word the LSI application is articulated by 8 Interactive Scenes / Virtual Scenario such as:

I. Tracking the Vanishing Point
II. Interactive Square (Point of arrival)
III. Santa Maria delle Grazie
IV. The Refectory
V. The Last Supper
VI. The Center of Projection
VII. Interacting with Alberti’s theorem virtual tool
VIII. Exit(s)
5.4.5.2. **User Interactions with LSI Interactive Scenes (Virtual Scenarios)**

1. **Tracking the Vanishing Point**

2. **Interactive Square (Point of arrival)**

3. **Santa Maria delle Grazie**
From the Interactive square the user is teleported in front of the Cathedral of Santa Maria delle Grazie. I look around the building, enjoying also the facade and the aerial views. Then I penetrate the wall: red wire frame lines forming the inner architectural structure of the church begin to appear; after some seconds, the space is filled by the complete structure composed in red wire-frame. Navigating within the wire of the columns, arcades, and vaults gives me a “real” feeling of the volume and space of this building. I am submerged in the music and the architecture of the entire space. A light beam fades in at the diagonal pointing to the direction of the refectories where inside is located the Painting of the Last Supper. When the user steps into the light beam, he is transported through a 3D vision direct inside the refectory in front of the painting.

*Figure12. MMB: Navigating toward Santa Maria delle Grazie*

*Figure13. MMB: Collage of the Milan church Santa Maria delle Grazie and the Last Supper.*

*Figure14. MMB: navigating within the inner architectural structure of Milan church Santa Maria delle Grazie.*

4. **The Refectory**

   Inside the refectory the user stands in front of The Last Supper in real scale at the distance of 8 meters on the groundfloor, 4.5 meters below the horizon and center point of the the 15th century mural painting (Italian: Il Cenacolo or L’Ultima Cena) created by Leonardo da Vinci for his patron Duke Ludovico Sforza and his duchess Beatrice d’Este. The original mural is painted on a wall of the refectory (dining hall) in the Convent of Santa Maria delle Grazie (Milan, Italy) and represents the scene of The Last Supper from the final days of Jesus as it is told in the Gospel of John 13:21, when Jesus announces that one of his Twelve Apostles would betray him. The simulation locates the user to see from the view point of the visitor in the real space and gives him b

5. **The Last Supper**

6. **The Center of Projection**

7. **Interacting with Alberti’s theorem virtual tool**

8. **Exit(s)**

6. **LSI project plan, next step**

The project plan next step is to pass on to Phase 6.

LSI Phase 6 encompasses two major goals:

1. Deliver an upgrade and improve standalone advanced Virtual Reality application of The Last Supper Interactive (LSIVR)

2. To accomplish the first phase development of LSI **Augmented Reality mobile application**: Augmented reality mobile application (for mobile devices and AR: iPhone, iPad, Android, Smartphone. (LSI AR)
7. Expected objective and deliverables of LSI virtual reality application Phase 6 are:

1. Upgrade and improved the application image visualization (stereo mode) to Ultra High Definition (4K or 8K)
2. Improved and enrich visualization of the 3D visualization and virtual creative content.
3. Improved visualisation and Interaction performances.
4. Improve the sense and perception of immersivity in the three-dimensional immersive virtual environments
5. Develop and incorporate new behaviors in navigation and interaction into the storytelling
6. Incorporate the sense of touch and haptic perception for a more sensorial and immersive experience (To incorporate the sense of touch and feel of object (the haptic sense) for a more sensorial and immersive experience with emphasis to the haptic interactions with virtual models in the context of real time immersive virtual reality user experiences. Adding the sense of touch, haptic feedback to previously visual-only solutions, engaging not only the visual and auditory senses of the users but also the sense of touch and feel of object will benefit the current application of LSI VR)
7. Develop and incorporate in three-dimensional visual space, music and the geometry of sound.
8. Deliver an upgrade and improved standalone advanced Virtual Reality applications of The Last Supper Interactive (VR)
9. New demonstration and exhibits
10. New conference presentation
11. New Publications

8. About LSI Augmented Reality mobile application (LSI AR)

Augmented reality mobile application for mobile devices: iPhone, iPad or Android Smartphone. (Work on progress)

8.1 Brief Intro: LSI Augmented Reality mobile application LSI Augmented reality mobile application is designed and developed for mobile devices: Smartphone, iPhone, iPad, Android and standalones: desktops.

LSI mobile Augmented Reality (AR) application is a project-based approach with intersection and juxtaposition of the physical world with the virtual, with focus on innovative perception and visualization in interaction on mobile devices; to experiment with the potential, particularly the advanced computing abilities and connectivity, enriching the user’s experience and encouraging personal exploration.
Last Super Interactive, the mobile application is designed to incorporate additional features that also assist in the provision of different layers of information with various ways and layers of navigating (e.g. spatial, chronological), the availability of images of high resolution and magnification, the linking and correlation of the system’s content and any link to additional online material’s.

The applications being developed taking in consideration the take advantage of the capabilities of the Smartphone technology (accelerometer, orientation of the terminal, etc.), magnification capabilities, ranging from small magnification to large one, access to details, high level of zooming via touch, offering images of high resolution and magnification suitable for examining details of an object. Providing for the possibility of bringing the works closer to the user, offering views which are often not necessary possible to acquire in other cases, adding value to the apps and enriches the user’s experience encouraging personal exploration.

LSI as the Augmented Reality (AR) application has been conceived as a stand-alone application, reliable on a 3G mobile network.

8.2 Mobile Augmented Reality and museums

Augmented reality mobile applications are suitable for museums which are open to explore new strategies for communication with current audiences, and for reaching new audiences. Through a personal device the user have chosen and are familiar with, not only during their museum visit, but also before and after the visit, wherever he/her chooses to be; with the ability to reach other users in conditions and at any environment of their choice; this opens up new possibilities for the communication of cultural content for life-long learning, edutainment and cultural marketing. Additionally, the fact that these users are connected in a wide network that offers like this possibilities not only for one-to-one communication between the cultural organization and the user, but also for social networking and creating like that communities of users interested in cultural content, incorporating network capabilities.

9. Exhibit, Presentations Last Super Interactive (LSI)

Last Super Interactive (LSI), have been presented, screened, exhibit in several places while was an ongoing project among which: Siggraph, USA; Imagina, Montecarlo, France; Art Futura, Spain; Ars Electronica Center Austria; Museo “Leonardo da Vinci”, Italy; Elder Museum of Science and Tecnologia, Canarias, Spain; MediARTech, Fortezza Da Basso, Florence, Italy; Teatro Central de Sevilla, Sevilla, Spain; Museo della Scienza e della Tecnica, Leonardo Da Vinci, Italy; ZKM|Media Museum, Karlsruhe, Germany; Museum Market of Trajan Rome, Italy; Vente Electronic Theatre, Fujita Research, Tokyo, Japan; Elder Museum of Science and Tecnologia, Las Palmas de Gran Canaria, Spain; Circulo de Bellas Artes, Madrid, Spain; Hellenic Foundation, Athens, Greece Art Futura, Spain; Salon B.it, Italy; MediARTech, Italy; Imagina, France; Mediaterra, Greece; and Palazzo dell’Esposizione, Italy; Museum of Palazzo Medici Riccardi Florence, Italy,

Further presentation, screenings, exhibit, publications, papers, article and other exposure can be provided upon request.

10. Credits

10.1. Credits LSI virtual reality application:

Author: Franz Fischnaller
Producer: F.A.B.R.I.CATOR
Collaboration:
Software development: Dave Pape
Technical assistance: Electronic Visualization Lab (EVL), The University of Illinois at Chicago, USA;
Dave Pape, Josephine Anstey, Tomoko Imai and Paola Trapani, Università degli Studi of Milan (I)
Special Collaboration: Electronic Visualization Lab (EVL), the University of Illinois at Chicago, USA
Sound: Giosè Casalotto (I)
Conceptual adviser during the first phase of development, and in part for The Last Supper: Daniele Marini, Università degli Studi of Milan (I)
The first 3D models of the Renaissance Buildings have been accomplished by Paola Trapani: Università degli studi of Milan (I)
A Segment of the application has been implemented at the Ars Electronica Future Lab within the Research & Residence Program by Franz Fischnaller and EVL.

During the first phase of development this work follows the first phase of a former research done by Prof. Daniele Marini and Arch. Lorenzo Forges Davanzati in 1982, aimed at proving a hypothesis about the shape and size of the virtual room, based on an application of the "costruzione legittima" theorem.

Other Partners, supporters and collaborators
The City Florence, the Municipality of the Region of Tuscany, the Tuscany Hi Tech Network, Italy, the Electronic Visualization Lab (EVL), and the University of Illinois at Chicago, USA; The City of Naples, Province of Naples, Assessor for the Cultural Goods, Municipality of Herculaneum, Region Campania CIVES Foundation, Agency Ville Vesuviane.

10.2. Credits: LSI Augmented Reality mobile application

Augmented reality mobile application for mobile devices: iPhone, iPad, Android Smartphone... (work on progress)

Author: Franz Fischnaller
Producer: F.A.B.R.I.CATOR
Collaboration: (Info to be completed)