

# “The Approval of the Franciscan Rule”. Virtual Experience among the Characters of Giotto’s Work

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## Abstract

*Within the exhibition “Giotto’s colours” opened to public from the 10th of April to the 5th of September 2010 in Assisi, the National Research Council realized an innovative project creating a virtual environment from the scene “The Rule Confirmation”, painted by Giotto in the Upper Basilica of St. Francis of Assisi at the end of the XIII century. The scene has been represented in 3D, starting from an accurate study of Giotto’s space, characters, proportions and the models have been “mapped” using the original artist’s painting. On this base two virtual reality installations have been realized. In the first one it is possible to virtually enter into the Giotto’s Fresco. The scene is brought to life: characters are animated and represented while performing the action painted by the artist. Visitors can interact within the virtual space and mix with the characters without the support of traditional interfaces (mouse, joystick, keyboards, devices) but just using body movements, in a simple and natural way. In this way the space illustrated by Giotto becomes a place of experience open to multi-sensorial narration and participation.*

*On the contrary, the approach of the second installation is descriptive and interpretative, focused on the spatial and perspective investigation of Giotto’s fresco, in comparison with the 3d reconstruction.*

*The primary objective of this experiment is to involve the observer in the scene painted by Giotto and to enable the visitor to feel and understand the message that Giotto was communicating.*

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## 1. Introduction

On the 10<sup>th</sup> of April 2010 an important exhibition has been opened in Assisi, dedicated to the restoration of Giotto’s fresco paintings in the Basilica of St. Francis, after the earthquake of 1997, and to the virtual restitution of the artist’s original colours. The exhibition, promoted by the Municipality of Assisi and the Franciscan Fathers, has been coordinated by the Italian Central Institute for Restoration [Bas10].

In this occasion the National Research Council realized an innovative project creating a virtual environment from the scene “The Rule Confirmation”, painted by Giotto in the Upper Basilica of St. Francis at the end of the XIII century. Starting from a very accurate analysis of the perspective, the view points, the proportion and the position of the elements painted in the scene, a complete three-dimensional model has been realized, matching as nearly as possible the original (figg. 1a -1b).

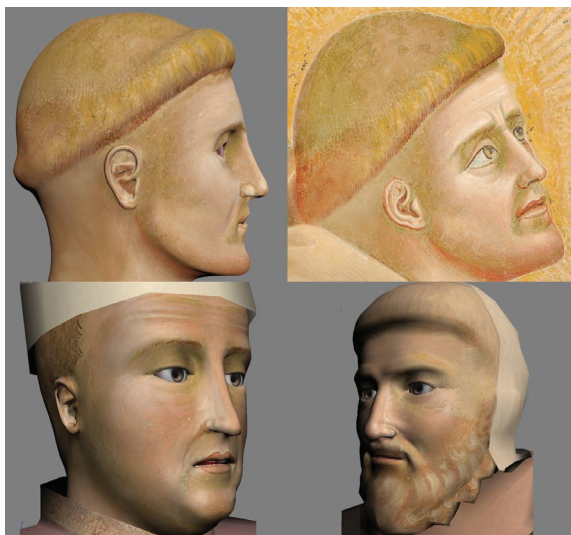
Giotto’s image was acquired at very high resolution and then it was subdivided in order to be used for the texturing of the 3D models. A wondering effect has been obtained, as it is possible to recognize the artist’s strokes and style on the volumes (fig. 2).



**Figure 1a:** *The Rule Confirmation painted by Giotto (actual condition of conservation)*



**Figure 1b:** *The Rule Confirmation represented in 3D (elaboration by Massimiliano Forlani)*



**Figure 2:** *Giotto's characters in 3D, mapped with the artist's original texture*

From the preliminary study of Giotto's fresco we deduced that the area in which Giotto placed the episode has approximately the following dimensions; width (walkable) 5.12m, height 4m, depth (walkable) 4m, although in the scene transformed for the interaction the depth has been slightly increased to allow the visitor greater freedom of movement, as we'll describe later.

The visitor can move in real time within this virtual environment, changing the view points, entering among the characters and live an experience of sensorial, emotional immersion into the scene. Through the personal involvement and the comprehension of the differences between 2D and 3D representation he can also understand some concepts and characteristics of Giotto's artistic style (fig. 3).

Basing on the same 3d models, two virtual reality installations have been realized, that will be described in the following sections of the paper.

The 3D volumes and characters have been realized in 3DSMax, Cat plugin was used for character animation and BonesPro for organic skinning; global illumination has been calculated in Vray and has been applied, where possible, through "render to texture" techniques. The final version of the 3D models, optimized for the real time interaction, counts about 1 million polygons. The models have been exported from 3DSMax in .fbx format, and imported in the real time graphic engine, Unity 3D.



**Figure 3:** *Giotto's scene represented in 3D observed from different points of view*

## 2. The Approval of the Franciscan Rule

In 1209, Francis led his first eleven followers to Rome to seek confirmation of their life and religious rule from Pope Innocent III. After some hesitations the Pope granted his unwritten permission. Contrary to other similar movements, Francis did not deny the authority of the Church, but considered the Church as "Mother" and offered her sincere obedience.

No trace survives of this original Rule, it was, probably, a collection of passages from the Gospel that were to be merged together, in the future, in the so called "Regola non bollata" written by Francis at the Porziuncola in 1221. This second version, more imposing than the original, was finally approved and signed in 1223 by Pope Onorio III.

In painting the Rule Confirmation episode, Giotto refers directly to *St. Francis' Legenda maior* (III, 10) written by St. Bonaventura from Bagnoregio (Bagnoregio 1217-1221 – Lyons 1274), itself based on the *two Lives of St. Francis* written by Tommaso from Celano (Celano 1200 ca. – Val dei Varri 1270 ca.), one of Francis' first disciples.

## 3. The first installation: *Virtual experience among the characters of Giotto's work*

The primary objective of the first installation is to involve



the observer in the scene painted by Giotto in such a way as to enable the visitor to feel and understand the message that Giotto was communicating, at least on an emotional level. In fact the space illustrated by Giotto becomes a place of experience, open to multi-sensorial narration and participation.

The installation is located in a dark space and the visualization is projected on a surface of 4x5 meters.



**Figure 4:** Real time exploration inside Giotto's scene represented in 3D

Visitors can physically enter within the painted scene, interacting in the virtual space and mixing with the characters (fig. 4) through natural interfaces, just using their body movements.

The scene itself is brought to life: the characters are animated, and they are represented while performing the action described by Giotto.

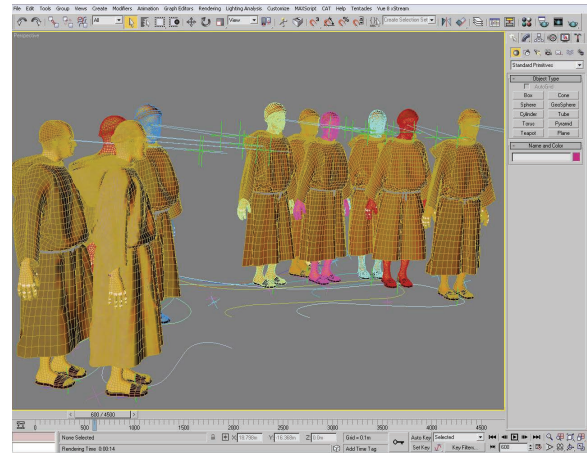
The installation includes three phases: 1) waiting, 2) storytelling, 3) real time natural interaction.

### 3.1 Waiting phase

The waiting phase is referred to the time when no visitor is present in the room. In this case a simple animation alternates the visualization of Giotto's fresco, in 2D, with its translation in 3D. The function of this animation is to attract the attention of the visitor who gives a look inside the room before he decides to enter, introducing the principal metaphor on which our idea of communication is based.

### 3.2 Storytelling

When a visitor enters the space of the virtual room, a 3 minutes movie will start and the 3D scene becomes animated. This is the narrative moment. The action portrayed by Giotto is dramatized before the eyes of the visitor who can watch it as it unfolds (fig. 5a -5b). Pope Innocence III and his following of bishops and prelates are in the room, waiting to be joined by Francis and his eleven disciples. Few seconds later the franciscan enter in the room and stop exactly in the places in which Giotto has portrayed them.



**Figure 5a:** Characters animation inside 3DSMax, paths setting



**Figure 5b:** Characters performing the action represented by Giotto in the virtual environment

Then a brief conversation between Francis and the Pope follows. Francis outlines the basic ideological tenets on which his proposed Rule is based and Innocence III, fortified by a warning dream of some nights earlier, gives his oral approval while exhorting Francis to preach penitence and to spread the Word of God.

The dialogue is based on the literary source used by Giotto: the *St. Francis' Legenda maior* written by St. Bonaventura from Bagnoregio.

As we said the movie is activated by the user's entrance in the virtual room but it is also reloaded every 12 minutes, in order to enhance the probability for public to see it (especially in consideration that the public flow is continuous).

### 3.3. Real time interaction through natural interfaces

At the end of this dramatized prologue, the third phase

begins: the interaction in real time. One of the project's most innovative elements is the paradigm of interaction which has been developed using natural interfaces. To encourage the perception of immersion, the scene is projected on a scale of 1:1 in respect of the space represented by Giotto, thus on a screen of 5 x 4m. Visitors can interact inside the virtual space simply by changing their position and moving their bodies in the real space, without the aid of any traditional interfaces (mouse, joystick, etc.), so in the most natural way (fig. 6), [CCP04], [VAR 90].



**Figure 6:** *Children playing with virtual characters in the interaction area*

When the visitor moves in the area in front of the projection (a space of about 5 x 4m) his position is identified and tracked – in coordinates xy on a horizontal plane – instant by instant by a motion capture system which is able to recognise and follow the visitor. This position is transmitted to the graphic engine which calculates and returns, in real time, the correspondent view point of the scene. In this way, the visitor, thanks to his own movements takes on the function of a tracer and has the sensation of entering and walking in the scene, moving between the characters, standing behind Francis or the Pope, being present at that fundamental fragment of history. The three-dimensional characters which populate the scene are animated and this contributes enormously to strengthen the expressivity of the simulation and to increase the visitor's emotional involvement.

Therefore icons, push-buttons, dialogue windows, keyboards, all disappear. What remains is the sensitive space of which the user is an integral part and, above all, an active element. The technology is modelled on the needs and the natural capabilities of a person, no particular knowledge or training is necessary to communicate with the system except that which comes from one's natural experience.

Music and sounds have another key role; environmental noises, murmurings, music are contextualized in the three dimensions. Medieval gregorian chant, poliphony fragments, contemporary electronic sounds are combined in order to create a very impressive suggestion.

The interaction can be managed by only one person at a time

but the public (up to about 15 people) can watch and take turns at interaction.

The system of motion capture is agile and low cost. There is no need for the user to wear markers or sensors because the whole system is based on the use of an infrared videocamera placed on the ceiling (figg. 7a-7b), which frames the interactive space, identifies the first user to enter and traces him while he remains inside the sensitive area. The interaction continues until the user leaves the area or changes places with another user.



**Figure 7a:** *Installation of infrared camera and videoprojectors for camera tracking on the ceiling*



**Figure 7b:** *VVVV motion capture engine, parameters calibration (developed by BCAA srl)*



The person traced by the system is illuminated and “marked out” by a bull’s eye light installed on the ceiling which follows him. This makes clear for the public who is the active user recognized by the software (fig. 6).

Motion capture is managed by VVVV 3d engine, based on Microsofts DirectX technology (fig. 7b), the graphic engine used for real time visualization is Unity 3D, a multi-platform game development tool.

#### 4. The second installation: *Virtual experience inside Giotto's space*

The second installation is very different from the first one but complementary; its approach is descriptive and interpretative, focused on the spatial and perspective investigation of Giotto's fresco, in comparison with the 3D reconstruction. The user can compare directly the 3D view and the 2D image by Giotto (the last one can be visualized with present colours and with hypothetical past colours elaborated by the Italian Central Institute for Restoration) (fig. 8) and he can interact freely inside the 3D scene, changing the view point in real time.



**Figure 8:** Main interface of the second application (desktop virtual reality): direct comparison between 2D and 3D representation for interpretative analyses about the space

Moreover the scientific rules of perspective projection with one central vanishing point are explained and simulated in the virtual environment (fig. 9).



**Figure 9:** Simulation of perspective projection on a plane, from one central vanishing point

In this way, one can examine how, where and why Giotto's construction differs from the correct perspective.

The three-dimensional reconstruction of the scene “The Rule Confirmation” offers a unique occasion to penetrate in the history of painting and to appreciate one of its fundamental step: the transition from the medieval, ancient, approach in representation to the modern approach, born during the Renaissance.

Giotto's image, in which the perspective simulation of space appears still very empirical, is compared with its three-dimensional translation.

What we can see in the 3D representation is the same scene painted by Giotto as if it would have been by, perhaps, Piero della Francesca, more than a century later, following the new perspective rules just theorized.

The perspective representation pursues “the illusion of reality”, a visual effect that makes a scene drawn on a two-dimensional plane appear as if it were three-dimensional.

Given a point of view, the scene is constructed in relation to it, according to precise rules of mathematics, optics and geometrical projection.

The comparison between the two representations allows to identify how and where Giotto's image diverges from the 3D that follows the correct perspective rules.

Giotto constructs the third dimension combining different perspectives, set on several, non corresponding vanishing points. His approach is still empiric and it often follows criteria of expressive exaltation rather than of proper geometrical projection.

Virtual reality constitutes, in a certain sense, a continuation of the “programme” of representation expounded by the theorists of the Renaissance – in fact it represents its ideal consummation. It is the “illusion of reality”: the systematic research of a way of portrayal which deceives the eye in such a way that the scene represented on a flat surface appears to be three-dimensional. In its “Treatise on Painting” Leonardo wrote: “The first marvel which appears in painting is that it seems to stand out from the wall or other surface and deceive the fine judgments with what is not detached from the wall's surface.”

The result in our virtual installation is obtained exactly as it was obtained by renaissance painters: by means of perspective the scene appears to the observer's eye exactly as if the wall/screen had disappeared and the scene could be observed made of solid bodies. The only difference between the procedure followed by the painter and that followed by modern technology is that the former had to calculate all the geometric projections himself while the latter uses a computer. This means that in this second case the calculations can be done infinitely faster than in the first; if the Renaissance artist took hours or even days, the computer usually takes a fragment of a second.

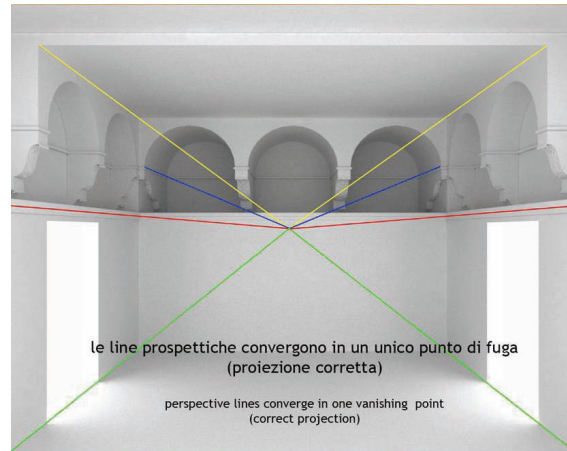
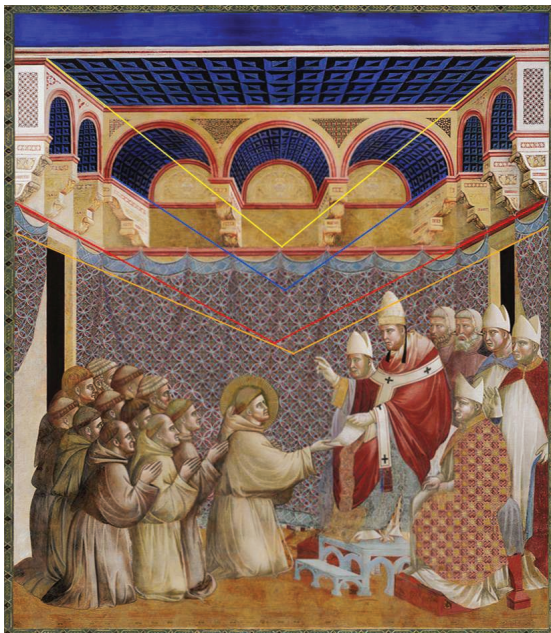
This condition allows to visualize a scene in “real time” and then to follow instantaneously any changes in the position of the view point. In this sense virtual reality completes the programme of the perception of illusion.

Thanks to these characteristics it is possible to set up a unique and exceptional comparison between Giotto's means of representation and the means used by the Renaissance

painters who came to fame a century later. It is therefore possible to analyse and understand this passage, not generically but focusing every point of their mechanisms. These are the main incongruences we identified comparing 2D and 3D:

- 1) The different proportion of the viewpoints: in 2D Giotto's image the height is a bit greater than the width; on the contrary in the 3D representation, made as faithfully as possible and including exactly the same elements of the scene, a rectangular viewport is needed, where the wide and the height have a proportion of about 4:3.
- 2) In Giotto's image the perspective lines don't converge in one vanishing point, differently from what happens in the correct 3D perspective view (fig.10a-b).
- 3) Characters located in different depth planes of the space are positioned on vertical levels laying one upon another. On the contrary, a correct perspective projection would hide characters staying in the rear lines.
- 4) The perspective result of the architecture seems to be obtained by a wide-angle lens. On the contrary characters seem to be shot with a telephoto lens.
- 5) Francis' and Pope's figures are larger than the others, according to the medieval use to represent more important characters in hierarchy larger in dimensions.
- 6) The Pope seems to stay in a more advanced plane than Francis but, in giving back the rule to Francis, he turns towards the public rather than towards Francis.
- 7) The arches at the top of the room are not congruent. It is not clear if they are extruded with respect to the angular edges of the room.
- 8) Doors seem too high, compared to the height of the structure.

The application was realized through the graphic engine Unity 3D and it runs on a iMac 27", 2.66GHz Quad-Core Intel Core i5.



**Figure 10a-b:** In Giotto's fresco the perspective lines do not converge in a unique vanishing point, differently from the 3D scene

## 5. Conclusions

This project constitutes one of the first example of real time, natural and immersive interaction inside a painted scene and it allows to test a new way of experiencing and learning the art, useful for students, children, common public and even for experts. The two installations give the opportunity to be involved in an original, inedited journey in Giotto's art and to look inside the history of pictorial representation. In fact the way in which the virtual reality technology functions in this case intrinsically allows one to appreciate, better than any other experience, one of the fundamental passages in the history of art – from the medieval, “ancient”, style of representation, to the renaissance “modern” style.

The three-dimensional reconstruction appears quite different from the original painting: we believe that through the perception and the interpretation of these differences we can identify, experience and think about the most important characteristics of the artist's style [FPR02], [Mel06].

Thanks to the use of natural interaction interfaces, the technology is modelled on the needs and natural capabilities of a person and no particular knowledge or training is necessary to communicate with the system except that which comes from one's natural experience [ABPP08], [Rya 01].

According to us in the next future this methodology will open great opportunities in the field of virtual reality, allowing all people to participate and to feel involved inside virtual environments dedicated to cultural heritage in an intuitive and amusing way [Ant04], [CBC07]. In the next projects we are going to develop the motion capture system further on, in order to multiply the possible behaviours and exchanges between real and virtual worlds [AP05], [Bat72], [Bat79].

It is possible to find material and movies about the project in the dedicated website [www.icoloridigiotto.it](http://www.icoloridigiotto.it).

## 6. The team

This project, coordinated by CNR, has been realised thanks to the creation of a multidisciplinary group which has brought together art historians, experts in digital technologies applied to cultural heritage, researchers, graphic artists, musicians, camera operators, and communicators. The scientific coordination and the technical direction are by Eva Pietroni (CNR ITABC), the project of communication and elaboration of the dialogues were directed by Francesco Antinucci (CNR ISTC). Our thanks go to Professor Roberto de Mattei, CNR Vice-president, for scientific supervision, to the Institute of Technologies applied to Cultural Heritage of CNR for the support in the integration of the system, to Massimiliano Forlani for coordination of 3D modelling, texturing and animation, to Francesco Verginelli for the elaboration of the digital models and the texturing, to BCAA and Claudio Rufa for the informatic implementation, the development of natural interaction, the music and sound, to the Laboratorio Romano for the movies, the backstage and the realization of the project website and finally to Hal9000-AltaDefinizione for the digital 2D acquisition of Giotto's paintings. The exhibition in Assisi has been coordinated by Giuseppe Basile from the Istituto Centrale del Restauro, it has been organized by Civita Servizi S.p.a. under the sponsorship of the Municipality of Assisi (Mayor Claudio Ricci) and in collaboration with the Franciscan Fathers of Assisi.

## References

- [ADV05] ALISI T., DEL BIMBO A., VALLI A.,  
Natural interfaces to enhance visitors' experiences, *IEE Multimedia* 12(3), 2005.
- [Ant04] ANTINUCCI F., *Comunicare il museo*, Laterza, Roma, 2004.
- [AP05] ANNUNZIATO M., PIERUCCI P., Emergenza e biodiversità della forma: l'estetica dello scambio tra vita reale ed artificiale, in *Proc. of the II Italian Workshop of Artificial Life*, Rome, 2-5 March 2005. Also in "Sistemi Intelligenti" (Il Mulino), Anno XVIII, n. 1, April 2006.
- [ABPP08] ANNUNZIATO M., BONINI E., PIERUCCI P., PIETRONI E., Cultural mirrors: an epistemological approach to artificial life for cultural heritage communication, in *Digital Media and its Applications in Cultural Heritage*, edited by Jamal Al-Qawasmi, Michele A. Chiuni, sabry El-Hakim, pp. 219- 135, 2008.
- [Bas10] BASILE G., edited by, *I colori di Giotto. la Basilica di Assisi: restauro e restituzione virtuale*, Silvana Editore, Milano, 2010
- [Bat72] BATESON G., *Steps To Ecology Of Mind*. San Francisco: Chandler Press,1972.
- [Bat79] BATESON G., *Mind And Nature: A Necessary Unit*. New York: Dutton, 1979
- [CCP04] CANTONI V., CELLARIO M., PORTA M., Perspectives and challenges in e-learning: towards natural interaction paradigms in *Journal of Visual Languages & Computing*, Volume 15, Issue 5, October 2004, pp. 333-345.
- [CBC07] CASTELLANO G., BRESIN R., CAMURRI A., VOLPE G., Expressive control of music and visual media by full-body movement, in *Proceedings of the 2007 Conference on New Interfaces for Musical Expression (NIME07)*, New York, NY, USA
- [CVC07] CASTELLANO G., VILLALBA S.D., CAMURRI A., Recognising Human Emotions from Body Movement and Gesture Dynamics, in *Proceedings of the 2nd International Conference on Affective Computing and Intelligent Interaction*, Lisbon September 2007.
- [FPR02] FORTE M., PIETRONI E., RUFA C.: Musealising the Virtual: The Virtual Reality Project of the Scrovegni Chapel Of Padua, in *VSM 2002, Proceedings Of The Eighth International Conference On Virtual Systems And Multimedia—"Creative And Digital Culture"*. Gyeongju, Korea, 25–27 September 2002: 43–52.
- [For08] FORTE M., edited by, *La Villa di Livia, un percorso di ricerca di archeologia virtuale*, ed. Erma di Bretschneider, Roma, 2008.
- [MV80] MATURANA H., F. VARELA., *Autopoiesis and Cognition: The Realization of the Living*, Boston Studies in the Philosophy of Science. Edited by Robert S. Cohen and Marx W. Wartofsky, vol. 42, Dordrecht (Holland): D. Reidel Publishing Co., 1980.
- [Mel06] MELLET-D'HUART D., 2006, A Model of (En)Action to approach Embodiment: A Cornerstone for the Design of Virtual Environments for Learning. In WIN W. & HEDLEY N., Eds. *Journal of Virtual reality*, special issue on education. Springer London. Volume 10, Numbers 3-4 / December, 2006, pp. 253-269.
- [Rya 01] RYAN M.L., *Narrative as Virtual Reality: Immersion and Interactivity in Literature and Electronic Media*. Baltimore and London: Johns Hopkins University press, HB, pp. 399, 2001
- [VTR91] VARELA F., THOMPSON E. - ROSCH, E., *The Embodied Mind. Cognitive Science and Human Experience*, MIT Press, Cambridge, 1991.
- Natural Interaction, article on Museum practise:  
<http://naturalinteraction.org/index.php> entry=entry070224-123657
- [Var 90] VARELA F. 1990, *Il corpo come macchina ontologica*, in M. Ceruti, L. Preta 1990, pp. 45-54.

[Var 99] VARELA F.J., *Quattro linee guida per il futuro della conoscenza*, in *Argonauti nella Noosfera. Mente e cuore verso nuovi spazi di comunicazione*, Vol. 2, *strutture ambientali* n.118/dicembre 1999, Proceedings of the 25<sup>th</sup> Ed. of International Conference promoted by Centro Ricerche Pio Manzù