Cyber-Archaeology: Notes on the simulation of the past

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Resumen

Trece años después de la publicación del libro "Arqueología virtual" (Forte, 1996, 97) es el momento de volver a discutir sobre la definición, los conceptos clave y algunas nuevas tendencias y aplicaciones de la arqueología virtual. El presente documento analiza la introducción del término "cyber-arqueología" en relación con el proceso de simulación derivado de la interconexión y la retroalimentación multivocal y entre los usuarios / actores y ecosistemas virtuales. En este nuevo contexto de mundos cibernéticos, es más adecuado hablar de simulación del pasado que de reconstrucción del pasado. La multivocalidad de la simulación abre nuevas perspectivas en el proceso de interpretación, no imponiendo la última reconstrucción, sino sugiriendo, evocando, simulando múltiples resultados, y no "el pasado", sino un potencial pasado.

Nuevos modelos epistemológicos de la arqueología cibernética deben ser investigados: Que ocurre en un entorno inmersivo de arqueología virtual cuando cada usuario es "materializado" en el espacio cibernético? La ontología de la información arqueológica, o la cibernética de la arqueología, se refiere a la interconectividad de todas las relaciones que produce el dato, el código de envío, y su transmisibilidad. Porque depende de las interrelaciones, por su propia naturaleza, la información no puede ser neutral con respecto a la forma en que se procesa y percibe. De ello se deduce que el proceso de conocimiento y la comunicación han de ser unificadas y representadas por un único vector. La información 3D se considera como el núcleo del proceso de conocimiento, porque propicia la retroalimentación, entre el usuario, el científico y el ecosistema. Se argumenta que la Realidad Virtual (tanto fuera de línea como en línea) representa un posible ecosistema, que es capaz de ser anfitrión de los procesos de conocimiento y comunicación tanto de arriba a abajo como de abajo a arriba. En estos términos, el pasado se genera y codifica por "un proceso de simulación". Así, desde las primeras fases de adquisición de datos sobre el terreno, las metodologías técnicas así como las tecnologías que usamos, influyen de manera decisiva en todas las fases de interpretación y comunicación. A la luz de estas consideraciones, ¿cuál es la relación entre la información y la representación? ¿Cuánta información quedará incluida en el modelo digital? ¿Qué clase y cuántas ontologías deberían ser elegidas para permitir una transmisibilidad aceptable? De hecho, la comunicación arqueológica debe ser entendida como una fase de validación de todo el proceso cognitivo de comprensión del conocimiento, y no como una simple adición a la investigación, o como un compendio de los datos prescindible.

Palabras Clave: *CYBER-ARCHAEOLOGY, INTERACTIVIDAD.*

Abstract

Thirteen years after the book "Virtual Archaeology" (Forte, 1996, 97) it is time to re-discuss the definition, the key concepts and some new trends and applications. The paper discusses the introduction of the term "cyber-archaeology" in relation with the simulation process deriving from the inter-connected and multivocal feedback between users/actors and virtual ecosystems. In this new context of cyber worlds, it is more appropriate to talk about simulation of the past rather than reconstruction of the past. The multivocality of the simulation opens new perspectives in the interpretation process, not imposing the final reconstruction, but suggesting, evocating, simulating multiple output, not "the past" but a potential past.

New epistemological models of cyber archaeology have to be investigated: what happens in a immersive environment of virtual archaeology where every user is "embodied" in the cyber space? The ontology of archaeological information, or the cybernetics of archaeology, refers to all the interconnective relationships which the datum produces, the code of transmission, and its transmittability. Because it depends on interrelationships, by its very nature information cannot be neutral with respect to how it is processed and perceived. It follows that the process of knowledge and communication have to be unified and represented by a single vector. 3D information is regarded as the core of the knowledge process, because it creates feedback, then cybernetic difference, among the interactor, the scientist and the ecosystem. It is argued that Virtual Reality (both offline and online) represents a possible ecosystem, which is able to host top-down and bottom-up processes of knowledge and communication. In these terms, the past is generated and coded by "a simulation process". Thus, from the first phases of data acquisition in the field, the technical methodologies and technologies that we use, influence in a decisive way all the subsequent phases of interpretation and communication. In the light of these considerations, what is the relationship between information and representation? How much information does a digital model contain? What sorts of and how many ontologies ought to be chosen to permit an acceptable transmittability? Indeed, our Archaeological communication ought to be understood as a process of validation of the entire cognitive process of understanding and not as a simple addendum to research, or as a dispensable compendium of data.

Key words: *CYBER-ARCHAEOLOGY, INTERACTIVITY.*

1. Introducción

1.0. About Cyber-Archaeology

Thirteen years after the first edition of the book I edited "Virtual Archaeology", this definition is popularized and we can count thousands of applications all over the world. What happened in all this period? Are this term and its implications still appropriate?

In 1996 I was describing virtual archaeology (fig.1) as "process of acquisition, restoration and re-presentation of archaeological data assisted by computers" (Forte, 1996). If this definition can well represent that period, we can also say that the 90's were representing a "visual age" in the domain of digital-virtual technologies in archaeology. This visuality was principally linked to the simple exploration and rendering of 3D graphic models, without involving complex interactions or behaviors in the cyber-space. This visual virtual archaeology was principally aimed to reconstruction process, without a real emphasis on the relations between the given information (for example the excavations) and the final 3D re-composition. Nowadays, I think we are passing from the first visual-virtual archaeology to a second age of cyber-archaeology. Why cyber? What is the main difference? Below we try to distinguish better the two areas of research and communication:

- Virtual Archaeology. Visualization Process, 3D mapping, Passive Users, Individual Environments, Migration from Analog to Digital

- Cyber Archaeology Simulation Process, Feedback, Behaviors, Content Providers, Collaborative Environments, communication from Digital to Digital.
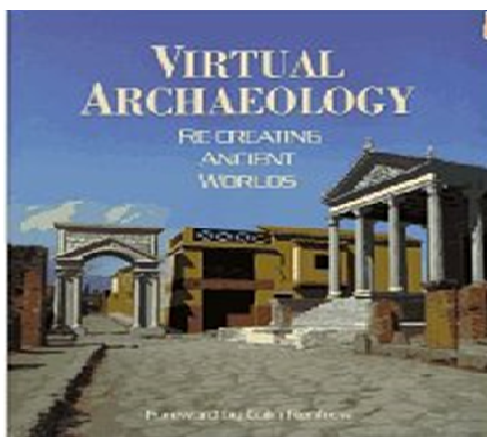

Figura 1. Virtual Archaeology (ed. by M.Forte)

There is not a real contraposition between the two terms (virtual and cyber), given the overlapping areas, but it is possible to identify specific characterizations. For examples in the 80s and 90s the conversion from analogue to digital data was very common, constituting a very time consuming and not linear process. Today the massive use of 3D scanners, GISs, remote sensing technologies and so on, characterizes the flux of data from a digital domain to another digital domain. In short, this new digital pipeline involves all the processes keeping possibly all the data in the same circuit of digital pre-processing, processing and post-processing: all in digital.

In fig. 2 I try to analyze the digital metabolism of the informational process from the fieldwork/data-entry to the various communication and transmission processes. Processing, interpretation, validation, interaction, feedback, cultural transmission, virtual communities, enaction-embodiment, constitute not a temporal sequence, but a possible circuit of cybernetic information. The information co-evolves according to different ontologies and it interacts with the environment. The cybernetic circle is based on the active role of the user as principal actor of the system and on the 3D interactions within the cyber-environment. In short the cybernetic circle produces a simulation process which is aimed to the simulation of the past and not on its reconstruction. The distinction between simulation and reconstruction characterizes the era of cyber-archaeology as science of the simulation of the past, a potential past.
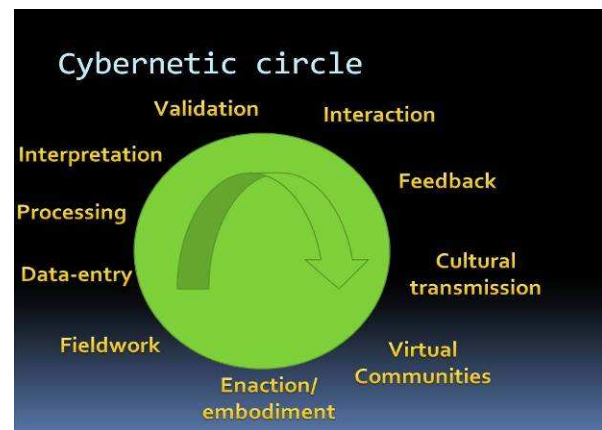

Figura 2 The cybernetic circle

This cybernetic past can be seen also as a rhizome (Deleuze, Guattari, 1987), a map, an informational code. The rhizome is a map and not a tracing. "What distinguishes the map from the tracing is that it is entirely oriented toward an experimentation in contact with the real. The map does not reproduce an unconscious closed contact with the real. The map does not reproduce an unconscious closed in upon itself; it constructs the unconscious. It fosters connections between fields, the removal of blockages on bodies without organs, the maximum opening of bodies without organs onto a plane of consistency. It is itself a part of the rhizome. The map is open and connectable in all ot is dimensions; it is detachable, reversible, susceptible to constant modification." (Deleuze, Guattari, 1987).

In the theory of rhizome I particularly like the metaphor of the puppet. "Puppet strings, as a rhizome or multiplicity, are tied not to the supposed will of an artist or puppeteer but to a multiplicity of nerve fibers, which form another puppet in other dimensions connected to the first: "Call the strings or rods that

move the puppet the weave. It might be objected that ITS MULTIPLICITY resides in the person of the actor, who projects it into the text. Granted; but the actor's nerve fibers in turn form a weave. And they fall through the gray matter, the grid, into the undifferentiated […]" (fig.3).

I think that the multiplicity represented by the nerve fibers of the puppet can well define and display the simulation process occurring in the multivocal interpretation of the past. The interaction depends on the inter-connection of any single element and the environment. The simulation creates a meta-model through a multiplicity of feedbacks, actions and output. Therefore the metaphor of rhizome can be considered pertinent on the reticular development of the information and on the cybernetic circuit of cultural transmission.
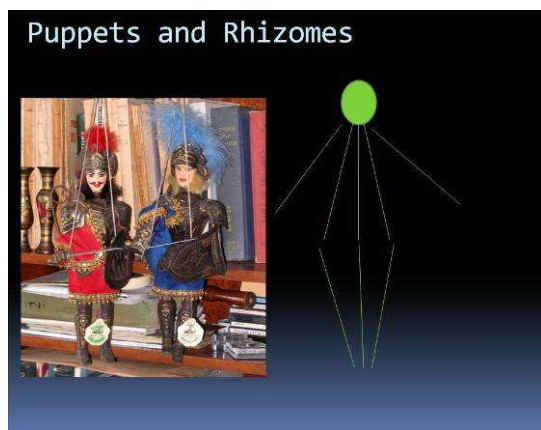

Fig. 3 Puppets and Rhizomes

1.1. The case of the Villa of Livia and the Virtual Museum

In January 2008, in Rome, the virtual multiuser Museum of Ancient Via Flaminia was open at the National Roman Museum (Museo Nazionale delle Terme di Diocleziano). One of the key archaeological sites reconstructed at different levels in the system is the famous Villa of Livia, wife of the emperor Augusts, located in the North-East part of Rome (Forte et alii, 2006, Forte, 2008). The virtual reality system consists in a virtual room provided with four interactive platforms. Users explore and share the virtual space through avatars: with their actions they create a virtual "show" which can be seen from the audience on a central stereo screen (fig.4).

On the main screen, through a general "script", different visual and informative contents show what happens in the virtual environment through the movements of the users/avatars. The "Virtual Museum of the ancient via Flaminia" and particularly the reconstruction of the Villa of Livia Drusilla (fig.5) is the first archaeological project developed through several media and technologies at the same time. The project's final aims are:

1. The reconstruction of a very important archaeological area, even if nowadays its consumption is very limited to the public: although open to the public, the villa is located out of the traditional touristic routes and

totally covered by a permanent roof which prevents the public to have a clear and complete overview of it. The villa is therefore difficult to understand either its archaeological structure and as in its historical and cultural value.

2. The recontextualization of landscapes, objects and monuments concerning the Ancient "Via Flaminia" and the Roman National Museum

3. The virtual reconstruction which aims at effectively communicating complex data throughout a direct and detailed view of the entire area in different archaeological phases.

Figura4 Virtual Museum of the Ancient Via Flaminia (Roman National Museum).

Figure 5: the archaeological site of the Villa of Livia (Rome). The coverage thwarts the comprehension of the monument

1.2. Methodology

The archaeology of the third millennium is able to process, interpret and communicate much more data and information than in the last two centuries. Are we aware of how much data can be produced and disseminated in this era? And how much fast is this process? In the 90's most part of research projects in virtual archaeology were technologically oriented; now we think

that in the third millennium they should be cybernetic-oriented. These informative-cybernetic models represent the focus of the methodology of validation and the scientific-cultural content we would like to send to the future.

But we have to pay attention: most part of what we study is relativized from subjective interpretation, then discretized from the output restrictions (ex. paper's space, color and resolution of photos, limits of drawing, accuracy of data, etc.) but not fully perceived in a path of final validation. The capacity to transmit knowledge and interpretation depends on a complexity of diverse factors: format, accuracy, argument, induction-deduction, communication, context, ontology. The object of knowledge transmission is what is perceived processed and finally communicated according to a constructivist logic (Watzlawick, 1985). To Piaget the organization is always the result of a necessary interaction between conscious intelligence and the environment (Piaget, 1980).

A path of research archaeological exclusively of taxonomic type (mostly bottom-up) is not ever complete, since it is not aimed to the comprehension and communication of the context, while, on the contrary, a syntagmatic approach, based on a chain of codes, meanings and relations, is strongly perceivable and reconnect the original code with the context (Antinucci, 2004). In the field of the ecological thinking it can be explained as a relationship map-territory (Bateson, 1972, 1979), where the map represents the information code (Korzybski, 1941) and the territory the information not yet coded. For example the archaeological landscape is a territory, while the ancient landscape is a map (Forte, 2003, 2005). Every archaeological context had from its origin a strong information-communication *autopoietic* content, which is able to produce meanings in its society, since the message is easily understood in its original context. Because of the spatial-temporal decontextualization, major part of this autopoietic code was lost; this is due to the missing meanings (for the observer and consumer) of the cultural and natural landscape and all the artificial relations with monuments and human actions. The archaeological research has from a long time enormous difficulties to face the scientific validation processes of the *datum*, mainly restricted to excavation reports or written publications. In terms of scientific validation how much is it possible to reconstruct of the long process of archaeological interpretation? Is the quality and quantity of produced information sufficient to validate the entire scientific pipeline?

The final response is in the validation system of data, in the transparency of interpretation processes, visualization and interaction and in the ability to codify and transmit information. In these terms we can consider Virtual Archaeology a cybernetic process and not a technological outcome. Our work was inspired by the second cybernetics of Gregory Bateson (1904-1980), by the study of relations between information, environment, organisms, ecosystem (Bateson, 1967), anthropology and ecology of culture (Ingold, 2000), by the concept of *affordance*-relation of the Gibson's thinking (Gibson, 1999). Following these premises we have studied the relationship between system and context of archaeological information. In particular we pay more attention to the cybernetic model (who follows rules of information transmission) than to the computerized model. The cybernetic model makes informative models, while the computerized model develops mainly tools of data processing. Therefore the cybernetic model represents a simulation process, an open virtual connective space where the information is generated by feedback's relations and by interaction.

In this paper I use the term "cyber-archaeology", preferred to "virtual archaeology" since I need to explain the complex ecological process/feedback used in the interaction with a virtual environment. Then I use the term "embodiment" to indicate the properties of interaction in a multiuser immersive virtual environment (Biocca, 1997; Gallese, 2005).

The creation of the "Virtual Museum of Ancient Via Flaminia in Rome, open in January 2008 (Forte, 2008), constitutes a good premise for discussing the role of cyber-(virtual)-archaeology in this digital age.

2.1. Cyber Archaeology

2.0. Virtual Archaeology

In the last decade the concept of Virtual Archaeology was discussed and popularized (Forte, 1997) with the description of many different scenarios. Most part of the discussions was focused on the value and potentiality of the digital reconstruction but I think that not enough attention was paid to the potentiality of the behavioral simulation processes. It is quite easy to follow the reconstruction process in an activity of digital modeling, but it is very difficult to explore the mental abilities of interaction in the cyberspace: here any action and feedback can produces new models of knowledge and interpretative processes. This condition of simulated and increased reality can be defined "hype-reality" (Baudrillard, 1994): for Baudrillard this kind of simulation is "more real than real". Even if the Baudrillard's interpretation of hyper-reality is very negative (the danger is that the Virtual can cancel the Real), this vision can help us to understand that the virtual represents a "dense", augmented information.

According to Maturana and Varela the specific dynamics of interaction and embodiment are able to increase the capacities of learning. The feeling of immersion in the virtual world is generated by a multisensorial involvement and by the inclusion of the user in the 3D space (Richardson, Montello, Hegarty, 1999).

It is through the mind-body that it is possible to know the virtual world and, to a lower level, models and information are processed. The virtual reality systems, as cognitive technology, interpret successfully an enactive approach to the cognition, such as computer and artificial intelligence interpret the cognitive hypothesis "(Morganti, Riva, 2006). The enactive cognitivism discusses the dichotomy between intern and extern: therefore cognition is an action "embodied" (Varela *et alii* 1991). In terms of enaction, the cognition depends on perceptual-motor experience and these capacities belong to a wider biological psychological and cultural context.

Thus the issue of the information's acquisition would be identified in the circularity between action and experience and between action and knowledge (Varela *et alii* 1991). Every existing object in the world depends on this perceptual-motor interaction. The object takes shape because of our activity and therefore we and the object take shape together (Varela, 1999, 66). The exchange of information in a virtual environment can be totally considered an exchange of information organism-environment.

In the evaluation of the cyber archaeological applications it is fundamental to know the epistemological commensurability. The increased information, its "density" constitutes the focus of a research path of virtual archaeology. In this assumption cyber archaeology is a system of communication and validation of the research approaches bottom-up and top-down; it is a *syllogis* of data and dynamic evidence not deductable by logics of feedback, that is behaviors able to generate other behaviors, actions making contexts and information. In the bottom-up approach we identity the operations of information input, in the top-down phases the actions of representation and mental patterning of information (Forte *et alii*, 2006).

Cyber Archaeology can represent today a research path of simulation and communication, whose ecological-cybernetic relations organism-environment and informative-communicative feedbacks constitute the core, but they have to be still fully investigated (Forte, 2007).

Yet if the cybernetic model is the focus, as example of interactive behavior, it is possible to study the relations between observers and models (both inter-connected). This aspect was in part discussed in the volume "Virtual Reality in Archaeology" (Forte, 2000): "It is useful, in fact, to notice that the major part of VA applications so far developed do not have important archaeological "contents", nor, as would be worthwhile, respond to precise questions. Instead they tend to float in a generically popular and multimedial sphere, or they are used as technological exercises or as a means of rendering the archaeology more spectacular; completely separate from the research context and from the exegesis of the data. Noticeable gaps are represented by the fact that the models are not "transparent" in respect to the initial information (what were the initial data?) and by the use of the peremptory single reconstruction without offering alternatives (it could have been like this but we can also offer other models...).

Figure 6: The virtual reconstruction in transparency of the frescos of the villa overlapped to the laser scanner model

Two issues over all: transparency of data and peremptory of the reconstruction are not enough considered in the process of multidisciplinary research (Forte, Pescarin, Pietroni, 2006). The transparency of data is a crucial issue because it involves the validation process and all the data entry until to the final architectural modeling. Understanding all the work allows to increase the cybernetic "difference" in the learning activity

between mind and ecosystem. To see in transparency means to verify the reliability of the work of virtual archaeology and to understand its development from the starting point to the final model. The issue then of the rigidity of the reconstruction (is there one reconstruction or many possible reconstructions?) can be solved in the relation of interaction between observer and model, namely in the dynamics of learning within the virtual ecosystem (Forte, 2007). The virtual reconstruction as research and communication process is always a selection between many possible reconstructions and it cannot represent ever the definitive solution for the archaeologist's job.

Cybernetic archaeology should become mainly the workshop of scientific research, an active and measurable space where to compare datasets, models, hypotheses, archives, a cyber space of interactive knowledge.

2.1 Cybernetic models and reconstructions

A simple correspondence virtual archaeology=reconstruction of the ancient world seems, in some terms, reductive, or, otherwise, oversized, utopian. Reductive because it seems finalized to the methods of structural architectural recomposition and not to the study of processes and relations between architecture-environment-organisms. Utopian because reconstructing the ancient world is interesting as method, but not realizable in a single process. Finally the transmission of an interactive and cybernetic model should allow also the future communities of scientists to continue our work, correcting our errors and suggesting new archaeological interpretations.

In epistemological sense the ancient world cannot be reproduced and reconstructed, but in the attempt to recompose the context it is possible to codify the relations/affordances which the space-time has canceled. In short we could say that cyber archaeology is aimed to the construction of spatial-temporal relations able to reconnect the territory with the "map", the archaeological landscape with the ancient landscape, following a validated and transparent methodological path.

The communication of any artifact or ecosystem depends on the transmitted and connected code. The reconnection of the relationship map-territory gives us the capacity of interpreting the past getting a major amount of information through the mutual interaction between observer and environment, where the same observer is part of the virtual ecosystem (Schroeder, 1997).

3. 3D Information

3.0 3D Environment

If our deeper knowledge of the environment is based from the perception of spatial coordinates and of the third dimension, a 3D digital ecosystem should be able to communicate a major amount of information and, mainly, to increase the dynamics of learning. The modality of perception and mental representation of the models contribute to the mediated knowledge of the world.

The Villa of Livia was fully documented by a time of flight's laser scanner (fig.6): it means that a laser spot of a few millimeters makes almost in real time a model of the Villa. At the beginning the model is around several millions of points, then, after the optimization and decimation in meshes and polygons is a few thousands of points. From this analysis it is possible to understand that new methodologies of archaeological research return us an amount of data much greater than in the past. This involves a different ontological phase, diverse perceptual levels and complex forms of communication. What can we do with all this digital? What happens between representation and knowledge? How much are we influenced by aesthetic-perceptive properties of the model? Communication and information of a model depend substantially on the interaction, namely we have to imagine a dynamic process modified by the movement, light, perspective, geometry and from all the relations with the environment. For example in fig.7 we can see two different versions of a wall (with plaster and painted decoration) of the Villa of Livia. The high resolution model corresponds to a model of 46.145 polygons generated from a point cloud taken by a laser scanner, while model at low resolution is reduced to 1237 polygons with a normal mapping processing. The visual perception of the two models is very similar, but do they communicate the same kind of information? It depends on the final aim and representation: if we want to make a detailed analysis of the geometry of the model (structural calculations, measurements, volumes, etc.), the version with 1237 polygons would be not enough. On the contrary, if we explore the model in real time, this perception could be enough for a first interpretation.
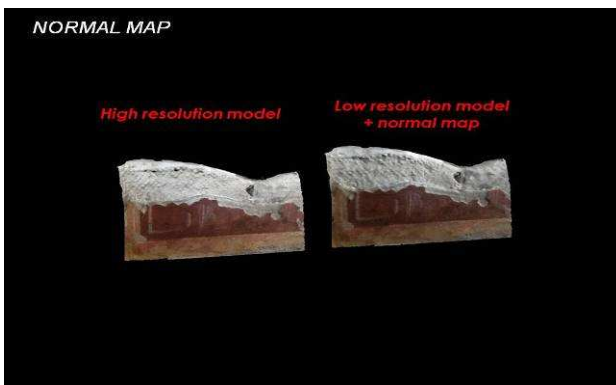

Figura 7: Normal map's application. Virtual reconstruction of a wall in high (left) and low (right) resolution

The perception in 3D spaces is a dynamic phenomenon and concerns firstly behaviors and effects. We list the main items:

Feedback. Each action in the virtual space involves a result and a rule of learning.

Behaviors. In the cyberspace it is possible to define pre-ordered and not pre-ordered events (for example the 3D navigation). Both categories enrich the virtual ecosystem, embodiment and capacities of learning.

Embodiment. Ability to see the body as a place of knowledge processing in the dynamics of the virtual. The places of embodiment are also those of the hyper-real, of the augmented space, of the digital ecosystem.

Difference. We learn through the difference: a difference generating a difference is an idea; a bit, that is an information unit (Bateson, 1979). The more is the difference between actor and ecosystem, the more is the capacity of exchange and communicates information. The representation in 3D creates a major difference in cybernetic sense; it means that interacting with datasets in 3D we develop a major exchange with the cybernetic ecosystem.

Space. The 3D space is inter-connected and homogenizes relations and objects in the same scale and size.

Multisensoriality. Virtual reality is multimodal and partially multisensorial (it is mainly based on audio-video). In any case even a partial involvement of our senses increases the perception of the three dimensions and characterizes the sense of place.

Light. The 3D navigation develops the sense of embodiment, the sense of space and the environmental properties. Different light conditions need a more complex reading of information and augment the capacity of environmental learning.

Transparency. The reconstructive process can be validated from a sequence of 3D worlds overlapping and spatially compatible.

Connectivity. The spatial information in a three dimension multiplies its communication model in a conceptual network of links.

Accuracy. The characterization of space depends on the spatial accuracy and on the abilities of representation and consumption of the models.

Cyber-realism. Setting and sense of place are correlated with the qualities of photo-realism or from the expectations of the observer in the virtual environment. The expectations of realism increase the level of familiarization and embodiment in the virtual environment.

MUDs and social communication. The agents within the system, for example avatars or subjective interactions, can learn through an unconscious imitation, following others' movements and by spatial sharing.

3.1 Cybernetic model

The cybernetic model of the Villa of Livia is a system of relations created by the real time interaction and navigation. It means that at theoretic level the cybernetic model does not have a preordered quantity of information, but it is progressively enriched by the explorations, integrating what is observing and what is observed (Forte, 2007).

The importance of the cybernetic model in comparison with the computational one is absolute, like the difference between logic and mathematics. For the cybernetics the information is the capacity of the organization level and complexity of a structure, in the sense that if a whole is random, it is not necessary to give some instruction for reproducing it (Wiener, 2001).

If the feedback constitutes the focal point of the informative dynamics, the description of the context is given from the relations. In a complex system the relations between elements are more important than the elements themselves (Forte, 2007).

The logic of a virtual reality system is similar to an anthill: each action can exchange a small amount of information with the

system, but in holistic sense the sum of several actions makes a more intelligent and evolved exchange. The logic of the anthill can explain the holistic interpretation of the villa of Livia in the cyberspace. In the exploration of the space of the villa, room by room, area by area, we progressively arrive to recompose the logic and connective unit of the monument as a coherent and working structure.

One more important issue regards the criteria for selecting non verbal communication and not explicit codes. Many relations in the cyberspace do not have a name or a label, but transmit information in the dynamic of the system. The communication happens between movement, interaction and representation (Wiener, 1948). In the archaeological landscape, partially visible and readable in the modern landscape, the code is represented by an interpretation of the past aimed to the reconstruction of the ancient landscape (Forte, 2005).
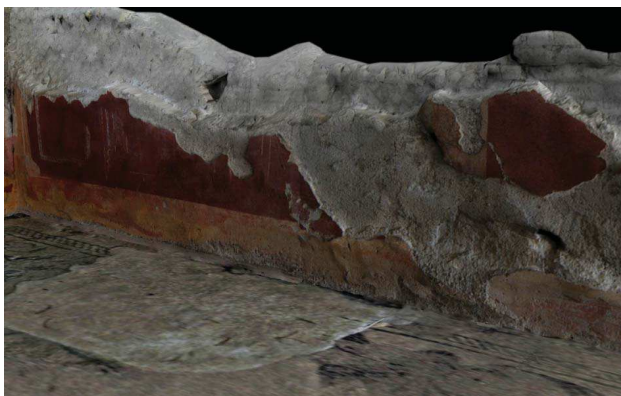

Figura 8: 3D visualization of a detail of a wall of the Villa, room 23, with plaster, frescos and chromatic components

This code is the map of the territory (Bateson, 1979), the interpretation key. Following these premises, the virtual reconstruction of the Villa of Livia is a simulation process: hence "the Villa" does not exist by itself, but the complex of potential and real relations linked with it exists, as *affordance*. The transparency of graphic materials used in the Virtual has allowed seeing trough the models, so that to have an easy structural comparison with the archaeological remains on site (figs.7-8). In this way the virtual anastylosis is interpreted as integration of the remaining architectural models.

The enactive vision introduces the definition of an embodied mind in the environment; for this reason it is an appropriate approach to a virtual ecosystem. In fact there is a strong link between world and observer: "A history of structural coupling that brings forth a world. This is the term for the reciprocal process by which an observer educes unities from her medium within the limits of her phenomenology (i.e., as constrained by her embodiment) and the ontogenic coupling results in incremental regularization in the structure of the observer (her embodiment)" (Varela *et al.*, 1991, 206). Then: "The fundament of an enactive account is not an objective ontological substrate, but the phenomenology of the individual defines enaction in terms of two intertwined and reciprocal factors: (1) the influence of an actor's embodiment in determining the trajectory of behaviors; and (2) the historical transformations which generate emergent regularities in the actor's embodiment". These two aspects can be mapped onto two different usages of the English

verb 'enact'. First is 'to enact' in the sense of 'to portray, to bring forth something already given and determinant of the present', as in a stage actor enacting a role. (Varela *et al.* 1991). The reciprocity of informative processes is the principle through which the observer is part of the virtual system, increasing its self-organizing capacity.

Each action in a virtual environment involves a feedback; the effect of this feedback is the perceptual-motor learning (bottom-up). In the case, for example, of a linear transmission of information (for example through a book), we have a symbolic-reconstructive learning (top-down). In cybernetic sense this mechanism can be described as in-out, or from the internal to the external environment, from the interaction to the learning.

In effect, the brain-training of the observer-actor, determined by the feedback of the system, allows an evolution to the use of the system with active and passive imitative processes. Active, when the observer learns from what he/she is doing, passive, when he/she learns from action of other users/observers.

3.2 3D Models in Archaeology

The balance of the last decades of archaeological research in the use of 3D documentation/representation in terms of scientific investigation is quite critical in terms of models distribution and public accessibility. The use of 3D models was typically oriented to display final reconstructions and not to discuss in detail the scientific interpretation. On the contrary, 3D modeling should constitute a bridge between knowledge and communication. It is remarkable to say that archaeological excavations using 3D technologies in the phases of acquisition and reconstruction are still a few. Therefore the documentation process is fragmented in many different ontologies (totally analog, partially digital and analog), where the 3D information is often missing.

A key problem in archaeology is that there is a strong gap between data capturing and data accessibility, because there is a very small percentage of information really open, communicated and public. The separation-segmentation of information in different domains (linear texts, models, spaces, maps, taxonomies, etc.) decreases the level of knowledge and does not validate the interpretation process. So the risk is to construct huge quantity of information free from any reliability and communication processes. It is a big challenge for the future of ICT and for the field of virtual heritage to plan the possible guidelines of cultural communication, and it is quite urgent to discuss about methods, technologies and epistemologies.

This shared knowledge constructs new differences and feedback, validates or criticizes models and cybernetic territories through simulation processes, creating unique opportunities of discussion and advanced forms of knowledge.

The most interesting perspective of this research project and innovative approach is in the redefinition of a virtual-cyber-archaeology as collaborative simulation process able to reconstruct the past through embodied communities of users/scientists. This distributed mind in the cyber space maybe represents the new frontier of our capacity of learning, understanding, communicating and transmitting culture.

4. Cyber Reconstruction

4.0 The Virtual Reconstruction of Villa of Livia

In the case of the Villa of Livia it is possible to access to the information's digital archive constituted by reconstructions, comparative models and graphic libraries. In short, the model is an open space aimed to grow and to be updated in the future, on the basis of further investigations on site or in post-processing. For what it concerns the issue of the reliability and congruity of the reconstruction three gradients (visualized with different nuances) have been conceived. The darkest nuance indicates a reconstruction which is totally scientific and reliable while the lightest indicates an evocative reconstruction that is based exclusively on generic cultural models of reference. In this way the virtual system is defined as a simulation environment and not as a simple virtual *maquette,* reproduction in scale of a hypothetic "original", just because this original cannot exists.

In fact, the creation of *maquettes* is closer to the idea of *replicas* than to the model of interactive simulation. The scientific coherence of the model in fact depends also from the faculty to distinguish the different ontologies of data: *in situ*, reconstructed, simulated, comparatives, dynamics, etc. It would be in fact too authoritative saying "this was the Villa of Livia in I cent. A.D.", while the simulation enables the coexistence of different hypothesis and models of reconstruction especially in relation to the special context and to the landscape.

In practice the dynamics of simulation in a cybernetic process permits the combination of a high number of factors, behaviors, artifacts, ecosystems whose focus lies in the process and not in the single element or in the formalization of unique elaboration.

The research prospective of cyber archaeology is therefore of a holistic and constructivist type: the reality of information is in the perception, in the capacity to identify the possible realities not THE REALITY. The Villa of Livia, as a model of knowledge is segmented in different domains: the villa *in situ* (figs.8-9), the villa through the sources and the excavation documentation, the villa and the landscape, the villa's reconstruction, the perception, the communication, the relations, the environment, all these and much more is the Villa of Livia Drusilla. The Villas of Livia therefore constitutes the ontology of information to interpret and communicate in reciprocity of intents of communication. A fundamental, I believe, mistake of virtual archaeology or maybe its original sin, was to separate the domains of knowledge and observation (what we know and we see today) from those of the hypothetic reconstruction, with the result of leaving visible and usable only the final state of the dialectic of interpretation.

For example the location of a site in the landscape, either in its original geo-context or in the relations with the ecosystem, multiplies the faculties of contextualizing the connection with other elements of the environment (figs.8-9), natural or artificial, as the parts of a monument are broadly speaking interconnected with its structure.

The methodologies of reconstruction in virtual archaeology, in particular with reference to the Villa of Livia can be classified schematically in this order:

Virtual Anastylosis: it deals with reconstruction of the ancient on an architectural and formal base in which the monumental space is privileged in respect to other possible simulations. In this case volumes and architectural forms are privileged in respect to materials, colours and textures. The Virtual Anastylosis can be also the first step to proceed to more complex reconstructions.

Evocative Models. In the evocative models the objective is to reconstruct by macro classifications, by comparative analyses without much attention to the relations with the data from fieldwork and to the spatiality of the information. In this category are included the graphic 3D libraries, the serial contextualized architecture of landscapes and every generic modal but identifiable in the cultural attribution.

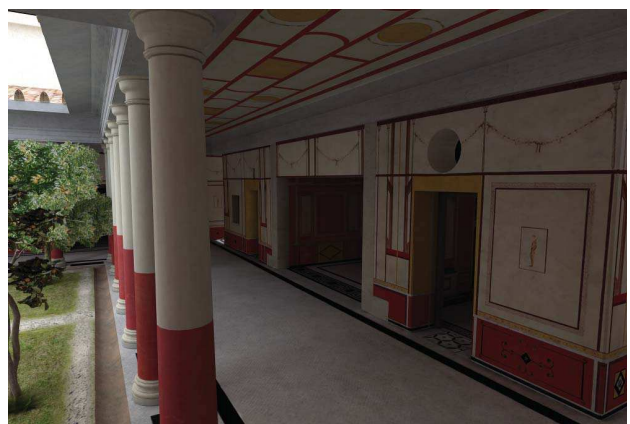*Figura 9. 3D model of the Villa of Livia by laser scanning data*

Figura 10. Villa of Livia, 3D reconstruction of the garden in the Republican age.

Hybrid models. They are models in which the reconstructed part (how the monument was in ancient times) integrates in transparency also the structures still preserved *in situ*. The hybridization is obtained from the coexistence of two architectural classes, real and reconstructed. In the model of the villa this hybridization makes easy the interpretation of the monumental structures (foundations and walls, fig.6).

Holistic reconstructed models. In this case the reconstruction integrates the architectural models, the textures and the furniture (fig.10). The simulation plans an integral reconstruction of the ancient villa.

Behaviors and organisms. They constitute the principal activities of avatars and agents: they can be active behaviors determined from users and passive behaviors identified as hypermedia links. For example an avatar-user meets a character in the virtual world which starts a movie or a tale.

Landscapes (fig.11). The artificial structures are fully integrated in the landscape and in the environment, whose physiography, vegetal coverage and ecological relations are reconstructed. Natural and artificial landscapes are not separated domains, but they are part of the same ecosystem.

Finally, the cybernetic reconstruction of the Villa of Livia (fig.13) is characterized by the following features: transparency and hybridization of the models, affordances, reliability and validation of the reconstruction, geo-spatiality, behaviors, 3D, embodiment, MUD.

Figura11: Villa of Livia recontextualized in the ancient Roman landscape.

Figura12 The network of ArchaeoPedia 3D across the UC campuses

4.1. Archaeopedia 3D

The increasing amount of 3D models, worlds and data in archaeology put new questions and mainly serious problems of accessibility. In particular the consumption of 3D interactions and behavioural models within the scientific community of archaeologists is quite low and disappointing. The usability and operability of these data and cyber spaces depend substantially by the availability of specific repositories and networks. Starting from these premises, at the University of California, Merced we have launched the project Archaeopedia 3D (fig.12).

The goal of this proposal is to establish a world-leading network of virtual heritage and collaborative environments in California (fig.12), by connecting pilot centers across five UC Campuses which will demonstrate to the world novel high-end techniques for collaborative learning in virtual heritage. The effort will enable the design, use, and study of collaborative environments for students, scholars and visitors. These collaborative environments will allow users to interact and learn in rich 3D virtual spaces, places where they can exchange data and information of cultural and multidisciplinary content. Immersive environments that permit scholars to collaboratively interpret reconstructed heritage artefacts, sites and landscapes will transform the study of history and archaeology.

The proposed activity will be based on participatory learning according to the integration of different immersive systems (Powerwall, Teleimmersive, Visualization Portal) and 3D web virtual environments. The production of 3D content for cultural heritage purposes has become exponential, with thousands of applications worldwide. However, very few are accessible, sharable and validated. This situation has an adverse impact on the interpretation process, in the sense that the virtual-simulation-reconstruction process remains an isolated experience without a public consumption, even within the scientific communities. In order to improve this situation, this proposal's goal is to create the necessary specific infrastructure where to discuss and improve interpretations in real time using three-dimensional tools, spaces and interfaces: virtual worlds, experimental labs, and simulation environments for collaborative work.

The proposed network of Virtual Heritage Centers has the potential to lead to valuable discoveries and improved technologies in the area of virtual archaeology but also virtual environments for learning and collaboration. A promising new direction in learning environments is emerging from the use of MUDs (multiuser domains) and collaborative environments where many users/avatars and digital communities can interact each other and exploring in the same time virtual worlds.

4.2 Scenario

As today's humanities scholars amass ever more digital information as the chief byproduct, or even product, of their research, the need for tools to access this data in fast-yet-meaningful ways will be fundamental to an education in the humanities. At the cutting edge of research, 3D laser scanning, remote sensing, global positioning systems (GPS) and geographic information systems (GIS), photogrammetry, and computer modeling have been used to collect and document

data on significant cultural heritage sites. Virtual reconstructions integrate the complex layers of archaeological, historical, and cultural data and provide the tools for scholars to visualize, analyze, and test hypotheses on the data. Yet despite the development of interactive technologies and virtual reality (VR) environments online and in a growing number of art and entertainment venues, adoption of VR technology for humanities research has not kept pace and there are few examples of 3D e-learning and e-communication. The display, sound, and information-retrieval capabilities of the virtual learning environment will allow scholars and students to experience information with a level of immediacy and fluency unheard of just a few years ago; more importantly, it will allow scholars and students to readily make connections between disparate pieces of information that would take years to make without this type of technology. Therefore, new conclusions about the relationship between the complex and many layered natural and human-built physical environment, on the one hand, and human action, on the other, will be possible.

5.0 Conclusions

The core of a cybernetic model in archaeology is the simulation relational process and the epistemological approach adopted. In this paper we have tried to redefine the role and the definition of virtual-cyber archaeology as a cybernetic simulation process. The focus of this process would be not in the reconstruction itself, but in the multiple relations and "differences" produced by the interaction between users, environment and behaviors.

It is quite urgent therefore to plan that, in the mid of the digital era and with so many powerful tool of information processing, the scientific process in archaeology has to be review, mainly in the relationship between knowledge and communication. The importance of the new tools and technologies used in archaeology creates still unexplored ontologies: remote sensing data, laser scanning models, photogrammetric models, virtual models, simulation environments. All this produces an enormous amount of data, whose scientific content is difficult to understand. What are the relations between acquired and represented data? Which capacities of analysis, interaction and simulation? How much information does a cyber model communicate?

The case study of the Villa of Livia has created a remarkable amount of models related with the architecture, landscape, and ecosystem. It has integrated the detailed reconstruction of the archaeological landscape (the site today) with the simulation of the ancient landscape (the site in Roman times). This study has suggested new paths in the integration of field technologies, new models of study and communication, until to the virtual museum, the last step of this holistic interpretation. All this is aimed to define a diverse model of knowledge and communication, nomadic, open, accessible and finally definable as ecological digital process. The spatial sharing in a MUD space stimulates imitative and mutual information processes, catalyzing the cultural transmission.

It seems hence quite evident as the methodology of the archaeological research has to provide adequate epistemological tools for understanding the cognitive geometry of a cybernetic model. In the dynamics of interactive communication, all this complex of information is cyber archaeology and it belongs to an innovative process of reticular learning, where the observer is part of the ecosystem. We think one has to go towards a diverse formalism of scientific research in archaeology, rethinking the information domain.

In the reticular learning which is distributed through dynamic and interactive models, the cybernetic frame moves from the flat area of the display to embrace the environment and the observer in a diverse cognitive and perceptive logic, maybe still to be defined; but it is there, close to the margins of chaos, that the knowledge starts.
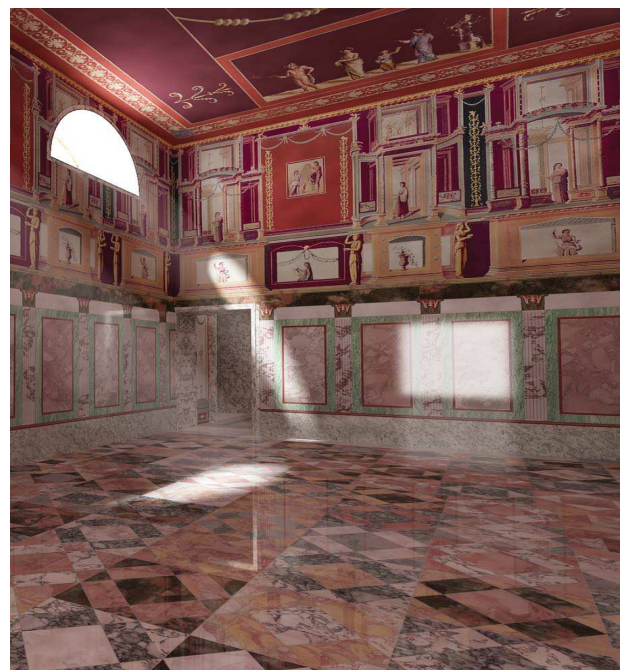

Figura 13: Villa of Livia, Southern part, room 6.

Acknowledgments

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