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THE VIRTUAL MUSEUM OF LANDSCAPE

> «If we call the world of 'things' of physical objects the *first world* and the world of subjective experience the *second world* we may call the world of statements in themselves the *third world*» (Popper 1974).

1. Introduction

A virtual museum of landscape regards, first of all, the process of virtualization of dynamic relations concerning the ecosystem, humans, animals, plants, soils, earth, water, etc. It is an artificial ecosystem, map and alphabet of the landscape itself, as will be discussed in the following chapters.

The landscape cannot be considered a static model, a snapshot, or a background-panorama, but as a live, dynamic and relational model within an evolving process. A virtual museum of landscape is focused on generating a holistic view of the environment, because without environment we cannot describe a landscape, and an ecological model. Ecology is concerned with living organisms and their interactions with their habitat, so the landscape can be perceived by the affordances generated by the environment. The word "affordance" was originally created by the perceptual psychologist J.J. Gibson (1979) to refer to actionable properties between the world and an actor. According to Gibson, affordances are environmental *relationships*, so in a landscape an affordance describes a property of mutual exchange between living organisms, objects and perception (it is real what we perceive to be real).

In methodological terms, the authors consider the landscape according to an ecological perspective: an ecosystem with multiple relations-perceptions, defined virtual affordances, creating places and mental maps: all these factors can communicate an holistic view of features, contexts, models, meanings. The final aim is not the reconstruction of a landscape's replica, but the creation of an open and evolving model, a scenario of simulation of artificial life, integrating different information ontologies. The problem of the "musealization" of a virtual landscape is particularly complex, because the issue of making a *real* landscape into a museum is also quite confused. What is a landscape? How should it be reconstructed? What kind of implications do we have in a virtual landscape, what relations? What is the final aim? Is it communicative or scientific?

2. Real and virtual museums of landscape

We live inside the archaeological landscape. Observing its diachronic aspects we can find traces, *disiecta membra* of the ancient landscape, that, unfortunately, are impossible to completely recall and reconstruct. We can

study it through a multidisciplinary approach and with integrated digital technologies; we can try to map its contemporary dimension and to acquire as many aspects as we can. We should start from *interpretative* processes on the data and on the information acquired, in order to reconstruct its natural dynamic and historical dimension: cultural, ecological and relational aspects could be analyzed.

We argue, in fact, there is no separation between knowledge and communication; the information re-contextualized within the landscape is a scientific and communicative attempt that gives a code to an unexplored system. When the study of an ancient territory can use more than the traditional archaeological approach based on the analysis of the "material culture", new research and investigation can be initiated, and new answers to unsolved problems can be found. The creation of *maps* could help our contemporary mind to interpret something that can no longer be entirely understood, because the cognitive horizon has completely changed. In this sense maps can be seen as keys to decode ancient landscape. The use of these keys is a contribution towards understanding problems that do not have any other archaeological evidence. The more codes we have, the easier it is to understand the landscape and its multiple relationships, which is the only way to perceive the context.

How should we communicate these studies to a wider public, of experts or non experts? How can we let visitors understand an archaeological landscape, the context of a site or a monument, the environment where an ancient culture was developed?

At present, there are not many answers to these questions, or at least not available to a community any more numerous than a restricted research group. What we can experience around the world are just a few solutions. If we want to understand how a territory was in the past, which is quite a common request for visitors and a stimulus for scholars, we can visit the place directly, or read a book, or go to a place that represents a "non-place", often very distant from the original context. In the first case, we are, for instance, in an archaeological or historical park with explanations, given in different ways or with different media-tools, on what we can see around us, what we cannot see any more, what is still preserved underground or in other places. In this case, the landscape is the museum of itself, of a static archaeological landscape. In the second case, we could be inside a "landscape museum" where dynamic and static aspects are explained with different tools, single elements analyzed through the evidence of some material, a territory approached synchronically and diachronically.

In our last year's work, such as in the case of the Aksumite virtual landscape (Forte, Kay 2003) (Plate I, a), the Vettii project (Forte *et al.* 2001), the Scrovegni Multimedia Room (Forte *et al.* 2004) (Plate I, b) and the Narrative Museum of the Appia Archaeological Park (Pietroni *et al.* 2005), we suggested

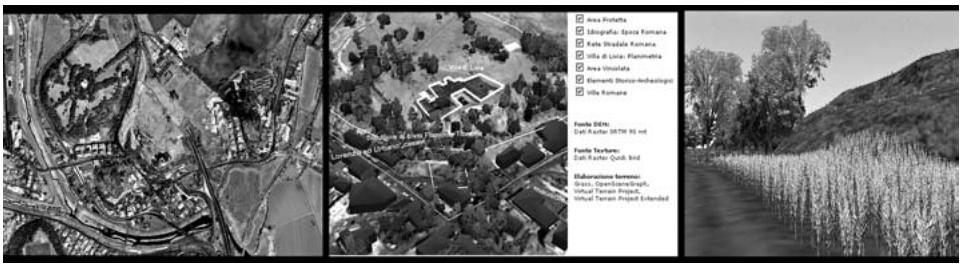

Fig. 1 – The archaeological landscape of Livia's Villa, via Flaminia Rome (left); an interactive interpretative map of the ancient landscape (webGIS, center) and a reconstructed hypothesis (right).

that Virtual Reality (VR) systems are a solution for this kind of complexity and dynamism. Even other Italian examples, available in on-line or off-line applications, have shown the same potential, such as the case of the Nume Project (Guidazzoli 1999) (Plate II, a), Virtual Bononia (Pescarin 2001), and the Certosa Virtual Museum (Guidazzoli *et al*. 2005) (Plate II, b).

In VR it is necessary to have feedback to explore a system: in fact, we learn through the difference we create between ourselves and the ecosystem (Bateson 1979). In reality, but also in virtuality, the affordances constitute the basis of feedback for generating information and, particularly in the case of landscape, for exchanging behaviors in an evolving scenario.

The self-organization, the *autopoiesis* of the landscape or better, of the environment, can create additional places where the spaces seem out of control, re-creating the "local" perception. This "re-created local" will create unplanned maps and feedback activities on the basis of the anthropological needs of the territory. The theory of mindscape, a virtual landscape perceived and interpreted by mental maps (Forte 2002, 2005), shows that the use of Virtual Reality is a key factor for the reconstruction of ancient mental maps because it involves the way through which we perceive information in time and space. In Bateson's ecology, without maps we cannot interpret the territory, because the map is the code; in the same time, the virtual museum can be the map of the landscape and its alphabet (Fig. 1).

In this scenario, digital technologies, archaeology and anthropology can have a social role, which is very important in reading the territory and in catalyzing the diachronic perception of the landscape. The understanding of landscape will have a *social impact* on local people, on tourists and visitors that, without "maps", cannot have the mental code of environmental interaction. Finally, processes of sustainable development cannot ignore a correct perception of the archaeological and ancient landscape. This trend towards spatial anthropology and remote sensing, supported by digital immersive technologies, should help the local communities to re-obtain power and sense of

Fig. 2 – Knowledge in the landscape. The case of "Appia Narrative VR Museum" in a public exhibit. "Building Virtual Rome", Trajan Markets Museum, Rome Sept-Nov. 2005.

place, and to guarantee an adequate cultural transmission. Even researchers and scholars can obtain good results in the use of VR for *landscape interpretation*. Inside an immersive or semi-immersive interactive 3D environment they could use also their perception and their sense of space-place to see if their hypothesis can "work" or to test new ones dynamically, in a more transparent and affordable process (Fig. 2).

In archaeology, in fact, a key problem is that in many cases the fieldwork is aimed at reconstructing a site and not a landscape, so it is difficult to have enough data for a consistent reconstruction and communication model. In this article we wish to consider the issue of the virtual museum of landscape in epistemological and technological terms, according to the digital protocol we have tested and implemented in the last years, from the fieldwork to Virtual Reality and VR WebGIS systems.

3. The reconstruction of the landscape

The landscape does not exist in terms of self-communication, namely without a code we cannot interpret it. The consciousness of landscape depends on the mental maps and on the capacity of perceiving the sense of place, what we describe as "mindscape" (Forte 2002, 2005). The mindscape is the visionary attempt to represent the landscape through mental maps, through the multiple perceptions created by the sense of place, by the consciousness of being "in" the environment (sense of place, feedback of place).

The principal questions for the landscape reconstruction are concerning the data we need for creating a virtual ecosystem. In general, in archaeological research (a part from a few cases) there is a fundamental lack of data on the paleo-environment and the landscape evolution processes. If we do not ask the correct questions, we will not have enough information for reconstructing the landscape and musealizing it.

In the following key points we suggest a list of components needed for mindscape reconstruction:

– Old archives. It is very useful to start from previous literature (digital, historical, texts, 2D, 3D, etc.) concerning any source of data regarding the landscape.
– GIS and remote sensing. The transformation and inclusion of GIS data is fundamental for digital reconstruction through time, because it allows us to keep the spatial dimension of each piece of information.
– Storytelling. The sense of place passes through memories, tales and perceptions.
– Earth components. Use of soil, information about the terrain resources (mineral deposits, activities, etc.), need to be correlated to human activities.
– Human factors. All the human activities in and out of the settlements, past and present. Taskscapes: all the activities finalized towards achieving a task.
– Eco-life components. Artificial life could be the challenge of the future: a simulated environment as an evolving process of information.
– Dynamic behaviors. The landscape has to be peopled by avatars representing 3D navigation, communication exchanges and interactions.
– Affordances. Identification of all the landscape's relationships able to generate behaviours and learning.
– Perceptions. The landscape as imagined according to multiple viewpoints.
– Mental maps. The interpretation of the landscape through the inhabitants represents the genetic code of its conceptual model.
– Places. The sense of place developed during the evolution of landscape in time and space.
– Anthropological view. Anthropological literature can increase our knowledge of landscape.
– Autopoiesis. The landscape can be imagined as an autopoietic system where living and self-organizing objects can have no predetermined behaviors.

The reconstruction of the landscape is not a static and closed process. On the contrary, it is a continuous process that has to deal with different environmental ontologies, in accordance with data sources and reconstructive patterns. In some previous works we described the digital pipeline that could be followed in order to connect different multidisciplinary activities and many different types of data in one unique integrated process (Forte, Pescarin

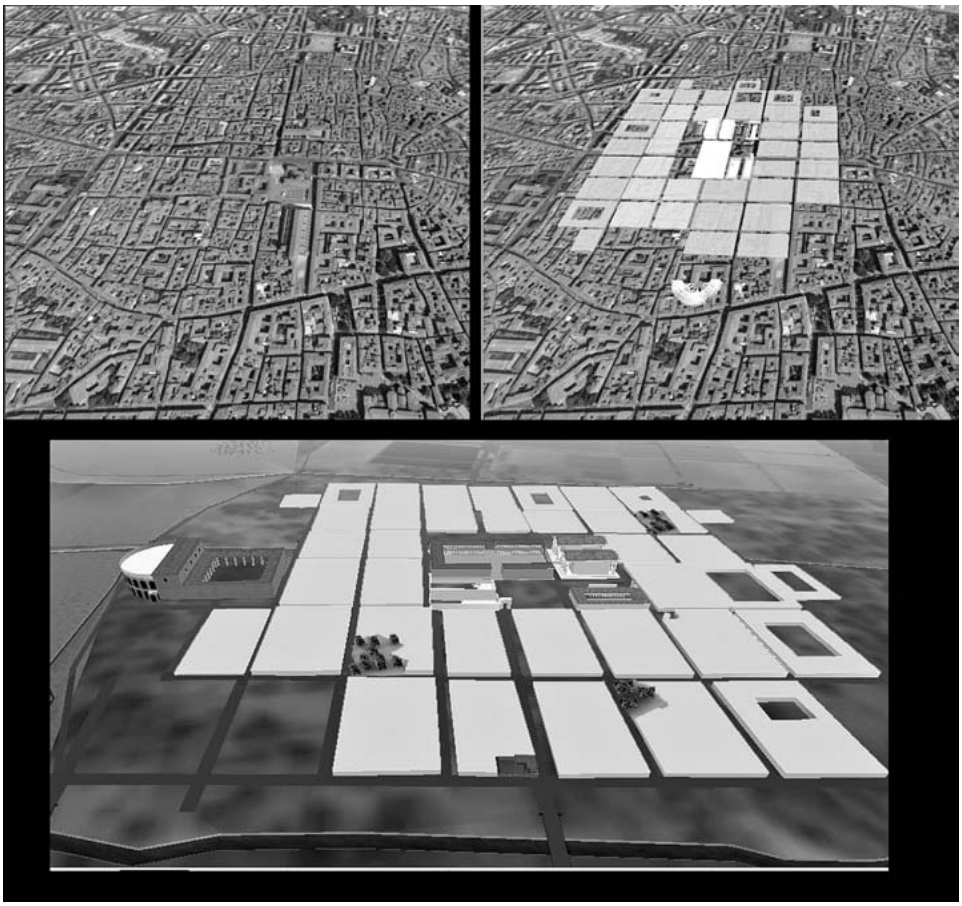

Fig. 3 – The territory of the city of Bologna. In an urban context it is often very difficult to perceive any trace of the archaeological past (left). Interpretative maps are helpful for the reconstruction of a landscape (center), but also as tools available in a communicative VR system (right) (Pescarin 2001).

2005, 56-66; Forte, Pescarin, Pietroni 2005, 79-95). *Spatial* component is fundamental and has to be maintained during the entire pipeline, from the acquisition to interpretation and reconstruction, in order to work within a revisable and updatable scientific process.

A key factor in a virtual environment is interaction: through dynamic behavior it is possible to construct and "de-construct" the landscape analyzing it as a whole or according each component or as a network (Figs. 2-3). In the case of VR WebGIS on-line applications, we have used this methodology

with open source formats and technology (Pescarin 2001; Pescarin *et al.* 2005). Through a menu a visitor can interact with the landscape, such as in the case of Appia Archaeological Park, uploading components, sources, vector thematic layer, 3D models of reconstructed monuments, vegetation libraries and so on (Fig. 4). In the near future we expect to develop more interactive behaviours inside VR web environments, letting the users define their paths, or researchers to upload or verify their contents (Forte, Pescarin, Pietroni 2005).

We are moving toward a wider integration of digital technologies in archaeology and this cannot be done without keeping VR dimensions in connection with a correct scientific process. The risk is quite evident. The reconstruction of a landscape is a simulation that can strengthen its evocative power. In fact, any virtual landscape, when it takes into account perception, cannot be considered as neutral; since it is not neutral and is strongly evocative, it can also conduct and force, sometimes, the final interpretation. This is perfectly normal in a narrative linear approach like a video production, for example, where the feeling of being involved is stronger than any other analytical brain processes. In VR systems, interaction keeps the brain "awake" and it is possible, at the same time, to keep narrative registers and communication paradigms. From the visitor's point of view, the more open the system is, the more active the learning will be through the activation of continuous differences (Bateson 1979); from a scientific point of view the more dynamic and shared the content is, the more open to new interpretations and better solutions the research process will be (Table 1).

Characteristics of a virtual museum open to visitors	Characteristics of a virtual system used by scientific community
Experience	Study
Game	Openness and Transparency
Interaction	More complex Interaction
Perception	Perception
Simplicity	Complexity
Involvement	Sharable
Interfaces	Flexibility
Design	Database, Query
Aesthetic	Updatability
Realism	Methods, Process, Techniques, Transparency
Information	Data
Contents	Metadata
Learning	Analysis
Communication	Research
Narration	Reliability
Immersion	3D, geo-spatial dimension

Table 1

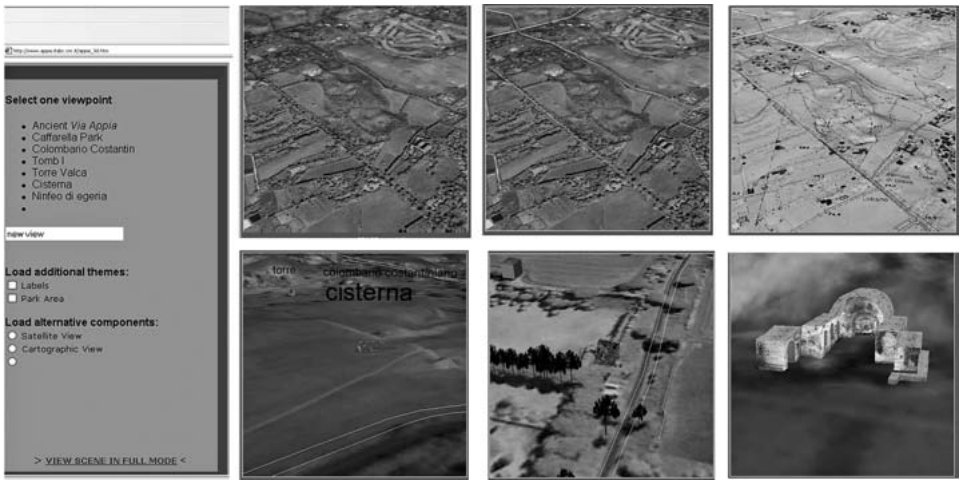

Fig. 4 – Appia Archaeological Park VR webGIS application (www.appia.itabc.cnr.it). Through the menu the visitor can deconstruct the landscape analyzing different components and source data (satellite images, cartographic maps, vector layers, 3D models, vegetation, etc.) (Pescarin *et al.* 2005).

4. Projecting the landscape: virtual affordances

A key issue for a virtual museum of landscape regards the capability of reconstructing what is communicative, perceivable and understandable according to time, space, ecosystems and different cultures. The act of mapping represents the interpretation codes we use for describing the environment. Initially, a culture which has produced a context is able to interpret it, to identify its relationships and meanings, because the "map" is in its own territory. When time and context have passed everything changes. The transformation of an ancient self-communicating context into an archaeological context, only partially communicating, is difficult to interpret because the original relations are removed and the interpretation depends on the capacity to reconstruct them; in this case the map is not in its territory, the archaeological map is not the ancient map. Maps, intended in a wider sense, are not the territory, but are fundamental in the interpretation-reconstruction process.

Hence, the core of landscape reconstruction cannot be a *static virtual set*, but a *dynamic environment,* co-evolving under the action of living agents (and in the future agents will be increasingly added to VR environment as well) and of interaction of immersive behaviours (today).

After having created an entire model of landscape, including all the environment (Fig. 1), it is necessary to project the possible affordances. As we have said above, the affordances determine the relations of feedback suggested and created by the objects and identifiable in the action of knowledge

of environment. An affordance can have a spatial, temporal, typological, functional, behavioural relation, as describe below (Table 2):

Spatial	Connects in space to other objects in a mechanical way
Temporal	Connects with objects of the cultural and chronological horizon
Typological	Connects with elements of the same type
Behavioural	The object/actor develops behaviours able to attract other behaviours
Functional	The object/actor is attracted by a task
Comparative	The affordance refers to other comparative models

Table 2

5. Future perspectives

Because the landscape is an autopoietic system, in the sense of Maturana and Varela (1980), a virtual museum is aimed at becoming an artificial ecosystem where the core will be represented by dynamic processes and behaviours. Actually, a virtual landscape is, in part, a predetermined space, where the interaction-navigation is free and personalized by the user, but the model is predetermined and unchangeable. In the near future the virtual landscape will be a simulation environment populated by artificial life, an open digital ecosystem where communities of users will interact in a multimodal way. Recent promising trends in information and communication technologies, identify a strong superimposition of different research disciplines: AI (Artificial Intelligence), VR (Virtual Reality) and AL (Artificial Life). The concept itself of "virtual reality" is changing, in the sense of a virtual environment with artificial evolving creatures (Annunziato *et al.* 2005).

Therefore, we expect to have a parallel evolution in the realization of virtual landscapes: off-line landscapes, dedicated to museum installations, where the immersion, the embodiment and 3D behaviours of users will be the core; on-line landscapes, where the development of virtual communities and artificial societies will involve a huge amount of users and interactions. In both cases, we have to imagine the landscape as a co-evoluted territory of multiple places, in which communication will be validated by the transparency of data, by the behaviour of users, and by the feedback-interaction produced by the virtual ecosystem.

The emerging integrated technologies able to keep the spatial data in the same ontological and digital domain, from the field to Virtual Reality, from off-line to on-line systems, will enable us, in the near future, to publish the archaeological data rapidly and in a unique digital protocol.

The virtual museum of landscape represents, therefore, the holistic vision of several digital components, processes, affordances, behaviours, systems, objects, where the "museum" is a metaphor of virtual ecosystems, the last and most evolved progression in the digital heritage.

Fig. 5 – A snapshot of the interactive exploration of a MuD, World of Warcraft (http://www.worldofwarcraft.com), where web users can share the same environment and experience.

6. Conclusions

According to a holistic approach we have to consider the landscape as a dynamic system of relationships, a living environment. The core of the activity of reconstruction is the integration of top-down and bottom-up activities, the combination of communicative and perceptive information (the *mindscape*) with the physical morphology (the *mapscape*). This integration contemplates the use of diverse devices/methods in the acquisition phase (remote sensing, GIS, DGPS, photogrammetry, and other field devices), different ontologies of data in the simulation environment, but it needs also to keep the spatial quality of information in all the transformation processes. The implementation, then, of open source software in the realization of virtual landscapes is particularly promising, because it guarantees the evolution of systems and methodologies for the research, apart from the policy of governments and multinational companies. Moreover, an "open" virtual landscape is really a space for experimentation, where users, stakeholders and scientific communities can dialogue freely and improve their feedbacks, differences, approaches and cultures.

The homology Virtual Reality-virtual landscape is correct because they are both systems, and for understanding and interpreting them we need to create a relational model, where behaviours and processes are the core, the virtual is

the map. Therefore, the museum of landscape has to embrace all the behaviours and relationships of present and past, of archaeological and ancient worlds.

In order to construct such a complex simulation environment, it is necessary to follow a digital protocol of reconstruction, starting from the field and concluding in a VR system and VR Web GIS. This process, that we can describe from knowledge to communication, is the basis for having a perceptual consciousness of landscape, according to a new path of learning and communication.

In conclusion, the landscape does not exist as a static and aesthetic model (scene, background, scenario or simple panorama), but as an evolving relational-behavioral system, an ecosystem visible in a holistic way through the perception of environment. In this sense, the virtual museum of landscape is paradigm of memories, holistic vision of the sense of place between past, present, and future. The key issue for the future is to share this process with a wide community of users-avatars, keeping all the behaviors within a 3D ecosystem.

There are several planned developments regarding, in particular, the web platform. Editing tools should be developed, in order to allow a real shared and working environment. Some guidelines regarding what to be published should also be considered as a priority by the scientific community. Moreover, web communities connected with VR WebGIS could represent an opportunity to share points of view, different interpretations and also diverse perceptions of ancient landscapes.

Simulations in virtual environments should be experimented more thoroughly, giving a complete 3D spatial dimension to numerical or statistical data. There are already some experiments in this direction, that bring together simulation as well as Artificial Intelligence, a field with enormous potentiality for the humanities as well.

In the future development of technologies, our research will be aimed at the development of multiuser collaborative network systems (MuDs, Multiuser Domains), where virtual communities can interact and dialogue as artificial communities (Fig. 5). In this sense the MuD can be seen as a non-predetermined environment where simulation factors and living organisms are able to create artificial societies. The sense of presence developing within a MuD could be the first step towards having a consciousness of mindscape, just starting from the creation of a virtual museum.

There is a common opinion that considers a virtual museum (in our case of landscape), as a simple tool for cultural tourism, e-learning, didactics, visualization dynamics; this is only partially true, but the virtual landscape is, first of all, the most advanced communication method for creating information, saving and generating memories, places and heritages.

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ABSTRACT

In this paper the Authors present the approach in the study and reconstruction of archaeological landscapes that has characterized their work carried out at CINECA Supercomputing Center of Bologna, in the Visualization lab (VISIT lab), and in the Institute of Technologies Applied to Cultural Heritage of CNR (CNR-ITABC). The digital pipeline defined in these years of work leads to the reconstruction of actual landscape (and archaeological landscape is part of our contemporaneity), past landscape, and ecosystems. The presented methodological model is a relational model, that uses both bottom-up (data processing from fieldwork with integrated technologies) and top-down (landscape reconstruction through conceptual models, comparative analysis and mental maps) approaches. Landscape virtual museums can be built as ecosystems made of models and dynamic behaviors, where data can be read in a transparent way because of their association with a visible ontology. The proposed digital protocol is defined by procedures, tools (hardware and software), exchangeable data/formats and technologies such as GIS, OpenGL graphic libraries, terrain generators, Open Source software. It integrates 2D spaces and 3D, raster and vector, grid and polygonal models, text and multimedia, with the goal of offering a real time access to cultural and environmental information through off-line and on-line Virtual Reality applications and, in the future, virtual communities that could share experiences in and of the same spatial 3D landscape-mindscape.